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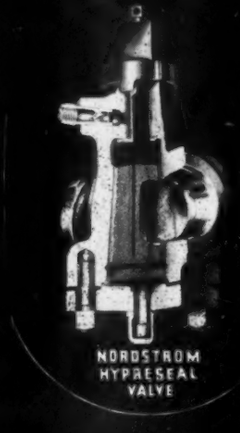
THE Petroleum ENGINEER
DALLAS, TEXAS

Every NORDSTROM VALVE a success!

in solvent treating *and* dewaxing plants



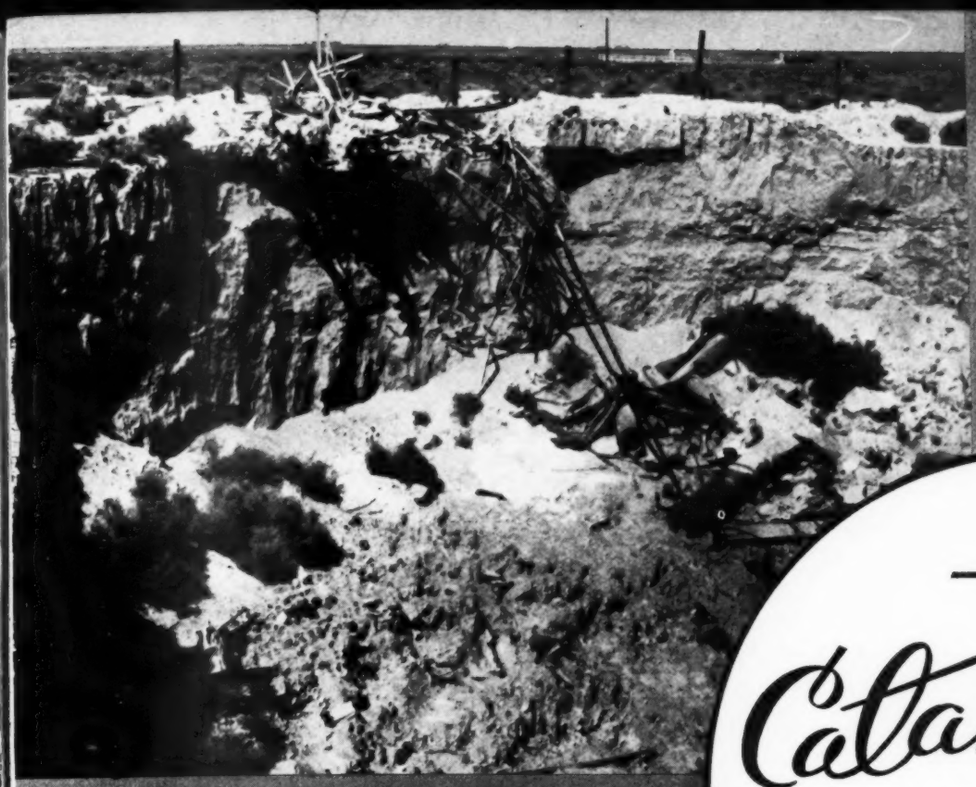
Valid patents granted Tretolite (the original inventor and developer of the most economical treating process) plus unexcelled facilities for developing universal and special processes for treating crude oil to pipe line requirements have assisted in maintaining Tretolite leadership. Tretolite processes are recognized as standard wherever crude oil is treated.

TRETOLITE COMPANY

MANUFACTURING CHEMISTS

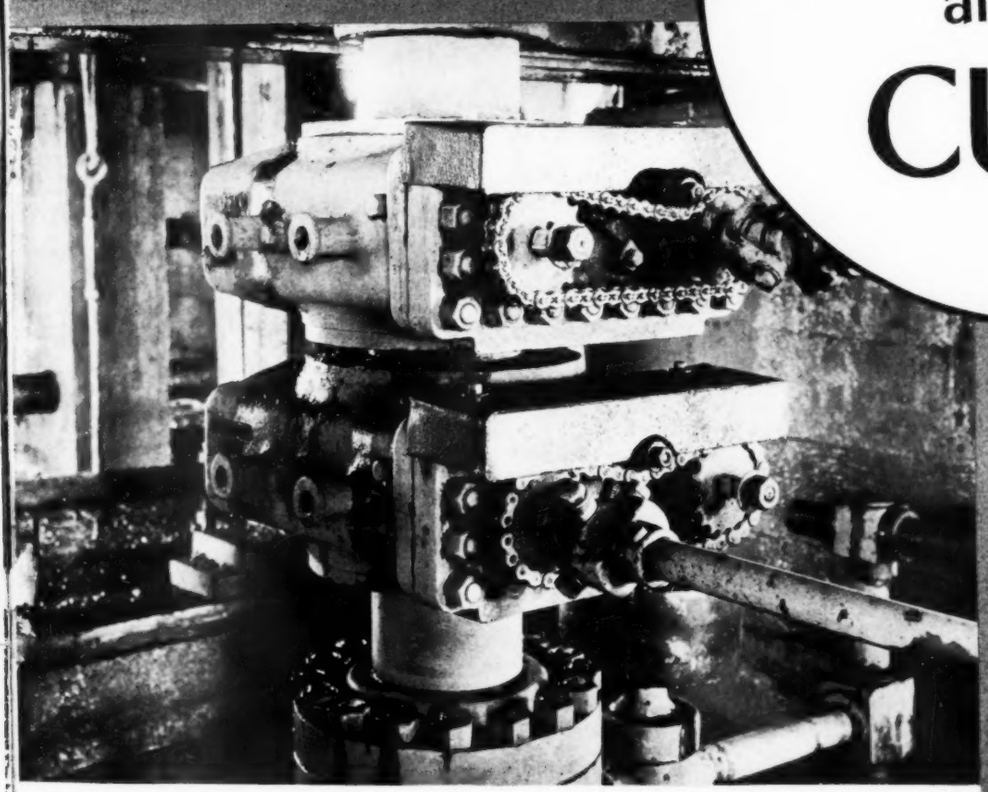
DALLAS **SAINT LOUIS** **LOS ANGELES**

Representatives in all Principal Fields



In 1927 a terrific blowout occurred in the discovery well in the Button Willow gas field in California. The entire rig disappeared in the crater formed by the blowout and to this day none of the drilling equipment has been found.

the Catastrophe and the CURE



A Typical Installation of Two Shaffer Cellar Control Gates at Belridge.

Two Shaffer Cellar Gates require little or no more vertical space in the cellar than one ordinary drilling valve. Shaffer Gates are tested to pressures up to 6000 pounds per square inch with an ample factor of safety. They will positively close and hold under all conditions encountered in modern drilling and will successfully hold high pressures indefinitely after being closed on the well. These gates may be operated manually or mechanically.

The year following this catastrophe Mr. Shaffer developed the Shaffer Cellar Control Gate which provides the maximum of safety against such blowouts when pipe is either in or out of the hole. The use of two Shaffer Cellar Control Gates provides positive protection against any contingency that may arise in drilling high pressure oil or gas wells. One gate is equipped with rams to close around drill pipe and the lower gate with rams for complete shut-off when pipe is out of the hole. They not only prevent blowouts but keep the well under positive control at all times and make it possible to tube wells under heavy gas pressure and make water shut-off tests by putting pressure inside the casing.

SHAFFER TOOL WORKS

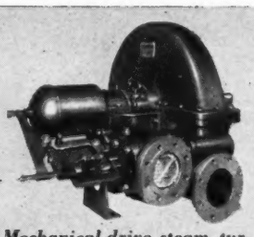
BREA, CALIFORNIA · HOUSTON, TEXAS
EXPORT-OIL WELL SUPPLY COMPANY

Let These G-E Products
BOOST YOUR PROFITS

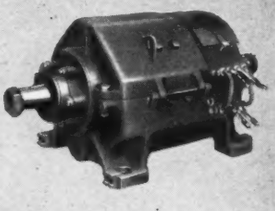
SOMEWHERE on the road from well to market, these modern, General Electric products will help you to save money. In production, in transportation, and in refining, G-E apparatus is ready to serve you. Ask the nearest General Electric or International General Electric Company office for further information; or write General Electric, Schenectady, N. Y., U. S. A.

Explosion-proof gear-motor. Class I, Group D, polyphase and single-phase types

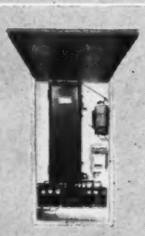
Explosion-proof manual motor-starting switch



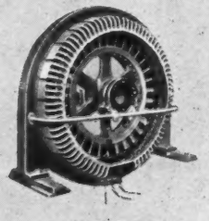
Mechanical-drive steam turbine, for driving mud screens, centrifugal pumps, and blowers



MD-400 direct-current motor, for rotary-rig drives



Control equipment in weatherproof cabinet, for outdoor use

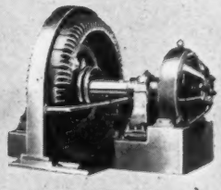


Low-speed synchronous motors, for direct drive of reciprocating compressor

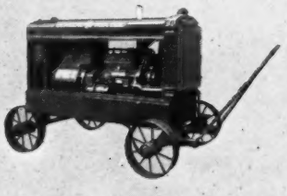
Outdoor switchgear unit, for controlling rotary-rig, engine-driven generators

Squirrel-cage induction motor with air intake and discharge through the base, for pipe-line pump drive

Distribution transformers available in ratings up to 500 kv-a. for commercial voltages up to 73,000



Diesel-engine-driven a-c. generators, for pipe-line pumping stations



Type WD gasoline-engine-driven arc welder

Open-type floodlight, for night work

011-59

GENERAL ELECTRIC

The Petroleum Engineer, issued thirteen times a year by the Petroleum Engineer Publishing Co., 405-409 Tower Petroleum Bldg., Dallas, Texas. Subscription price, $1.00 per year, except in Canada, where the price is $1.65 per year—15 cents a copy. Entered as second-class mail matter May 1, 1932, at the post office at Dallas, Texas, under the Act of March 3, 1879.

Hurry Pete...we've struck water

be sure there's some ready when you need it . . .

EAGLE LEAD WOOL

plugs off bottom water quickly!

Eagle Lead Wool Plugs seat off water quickly, effectively. Under tamping pressure, loose springy wool becomes solid plug. Seals tiniest cracks and crevices. *Non-corrosive.*

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THE EAGLE-PICHER LEAD COMPANY, CINCINNATI, OHIO

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The Kobe Pump is ideally adapted to modern well and field conditions; to wells of any depth; to straight and crooked holes; and for producing individual wells, or a group of wells from a central power plant.

The Kobe Hydraulic Pump incorporates the most advanced design in the modern trend toward portability. A complete pumping unit consists of two main sub-divisions, the Hydraulic Power Unit and the Production Unit. The Hydraulic Power Unit is completely weather and dust proof, requires no housing, and can be located at any convenient point on or near the well. The Production Unit is an insert type and consists of an engine and production pump combined in a single unit that can be pulled dry with the tubing and reset merely by removing one connecting tube, and without interfering with the remainder of the surface equipment. All units are extremely compact, completely self-contained, and practically 100% portable and salvable. Kobe engineers will submit complete, detailed data on installations, operation and performance records, without obligation.

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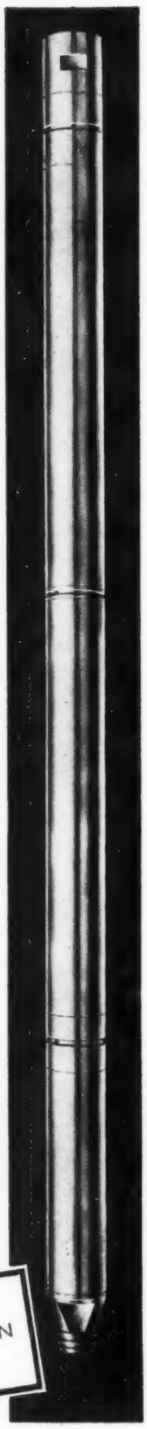
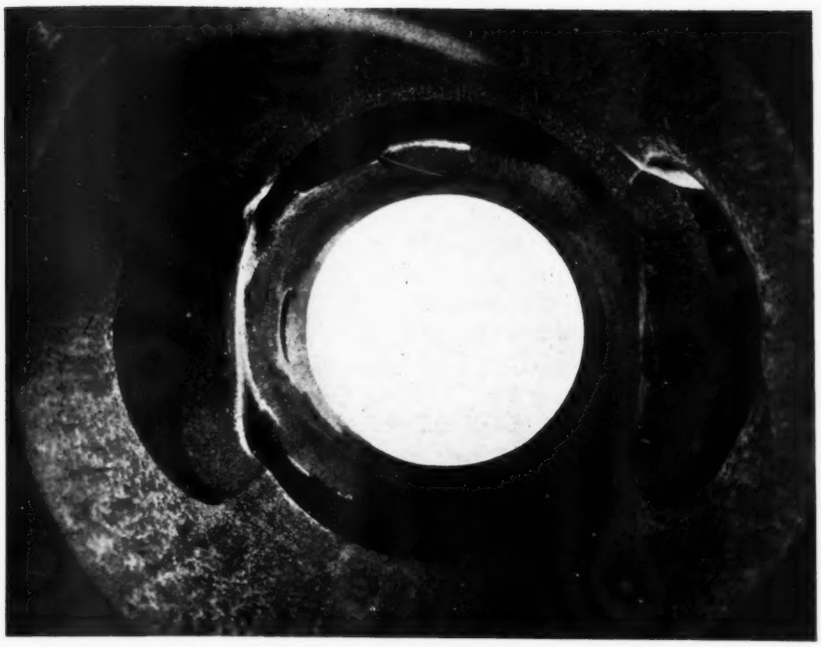
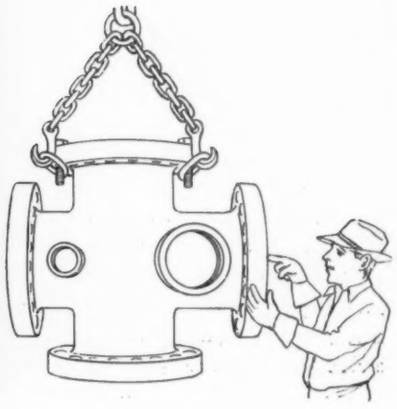


KOBE *hydraulic* PUMP
ALL-PURPOSE



Looking through the main bore of the Cameron 13⅝-inch Type "SDA" Blowout Preventer described below. Note how, in ten minutes open flow, preventer body was sand cut. Despite this cutting, Preventer closed and sealed instantly when control valve was opened.



DEEPLY SAND CUT, *but it sealed instantly and positively!*

...and saved at least $30,000 rig damage

The Cameron self-feeding ram packing element is a molded block of special rubber, supported top and bottom by steel retainer plates as illustrated. It is held in the ram by substantial steel dowel pins molded with the packing. Packing and retainer plates extend beyond the ram ⅛ inch. Packing is confined by steel except on surface which contacts pipe. In the 13⅝-inch size each packing element has 14 cubic inches of rubber in reserve, which feeds automatically as needed. When rams are closed, retainer plates in opposing rams contact and entirely enclose rubber packing material. Closing pressure forces rubber packing to flow to pipe surface, making a positive, leak-proof shut-off. Wear on packing due to rotation or spudding of drill pipe through closed rams is automatically taken up, and a pressure-tight seal maintained even on worn, irregular or under-sized pipe.

Without warning, a 5100-foot drilling well at Tomball, Harris County, blew out recently from an uncased upper formation. Pressure was estimated at 900 pounds, with heavy volume of sharp cutting sand. As the driller reached for the four-way control valve of his Cameron Type "SDA" (Pressure Operated) Blowout Preventer, and unnoticed by any member of the crew, he was struck by a master bushing blown from the rotary. About ten minutes later he recovered sufficiently to open the control valve, *and the Preventer closed instantly and sealed positively.* As shown by the photograph to the left, above, the Preventer was deeply sand cut during the ten minutes of wide open flow. Elevator and elevator bails, hanging eight feet above the rotary, were cut almost in two by the force of the sand.

This incident clearly demonstrates the remarkable sealing capacity of the Cameron Self-Feeding Ram Packing Element, regardless of adverse conditions beyond the control of the operator. This exclusive Cameron Ram Packing Element, *plus* high-speed pressure opening and closing, *plus* freedom to rotate or spud drill pipe under pressure to prevent sticking, *plus* 25 other notable features—make the Cameron Type "SDA" Blowout Preventer the outstanding unit of its kind on the market today. Full details cheerfully furnished on request.

CAMERON IRON WORKS, INC.

711 MILBY STREET **HOUSTON, TEXAS**

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FOR EFFICIENT CEMENT "SQUEEZE" JOBS

Gun-Perforate

Says "Perforating Pete":

"Didn't I tell you not to worry about your plug being higher than you had intended? We could have made that ring of perforations within a foot of the top of the plug if it had been necessary.

"You know from our record and your own experience that the Gun Perforator has provided just the type of uniform holes that assure your cement going out where it belongs.

"Also, don't overlook the fact that you got those holes without jarring your pipe and taking a chance of breaking up existing shut-offs above or below the point where this one was needed.

"The high percentage of successful shut-offs obtained by "squeeze" jobs through Gun Perforations certainly proves that we give you sufficient penetration to reach out to formation even through your old cement . . . and this is just as essential as the fact that you got the right KIND of holes.

"You know, too, that when you clean out to go after your lower production, you will find your pipe in perfect condition where we Gun-Perforated."

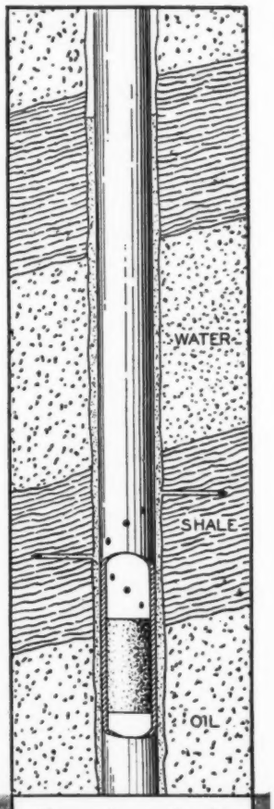
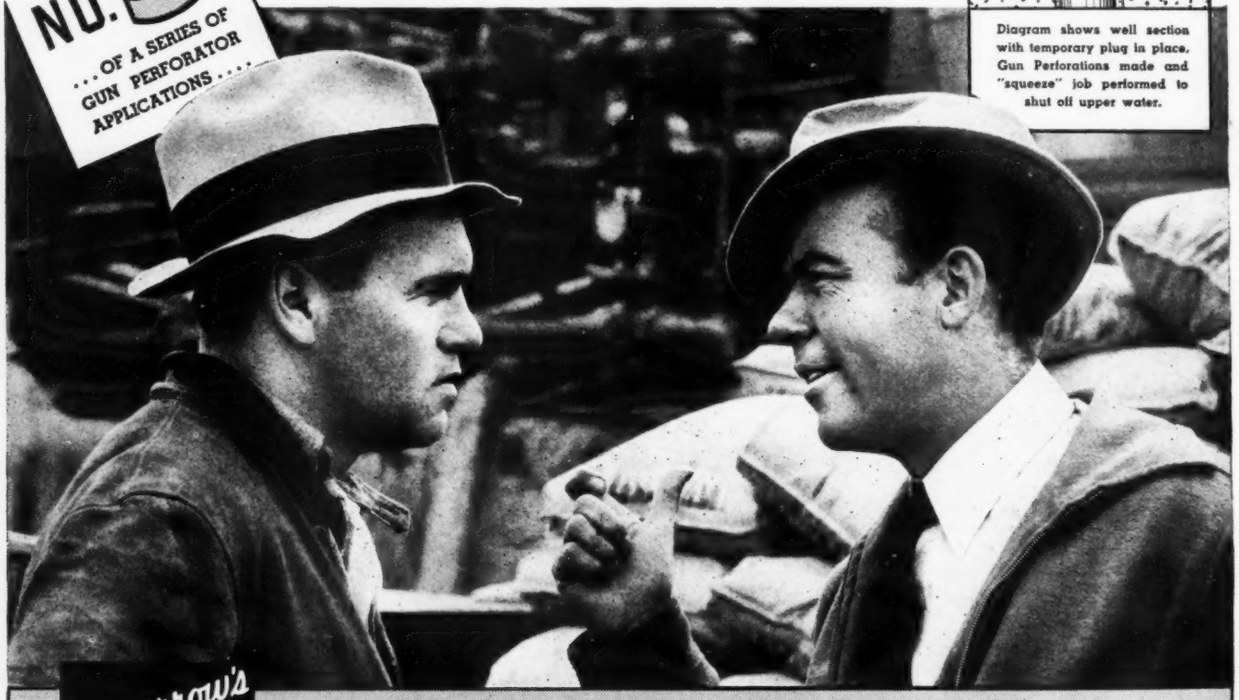


Diagram shows well section with temporary plug in place. Gun Perforations made and "squeeze" job performed to shut off upper water.

NO. 3 . . . OF A SERIES OF GUN PERFORATOR APPLICATIONS . . . .

Devices and method of operation licensed by Technicraft Engineering Corporation under Patents No.— 1,582,184; 2,029,454; 2,033,562; 2,029,478; 2,029,491; 2,029,490.



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THE LANE-WELLS CO.

Gun Perforator Service

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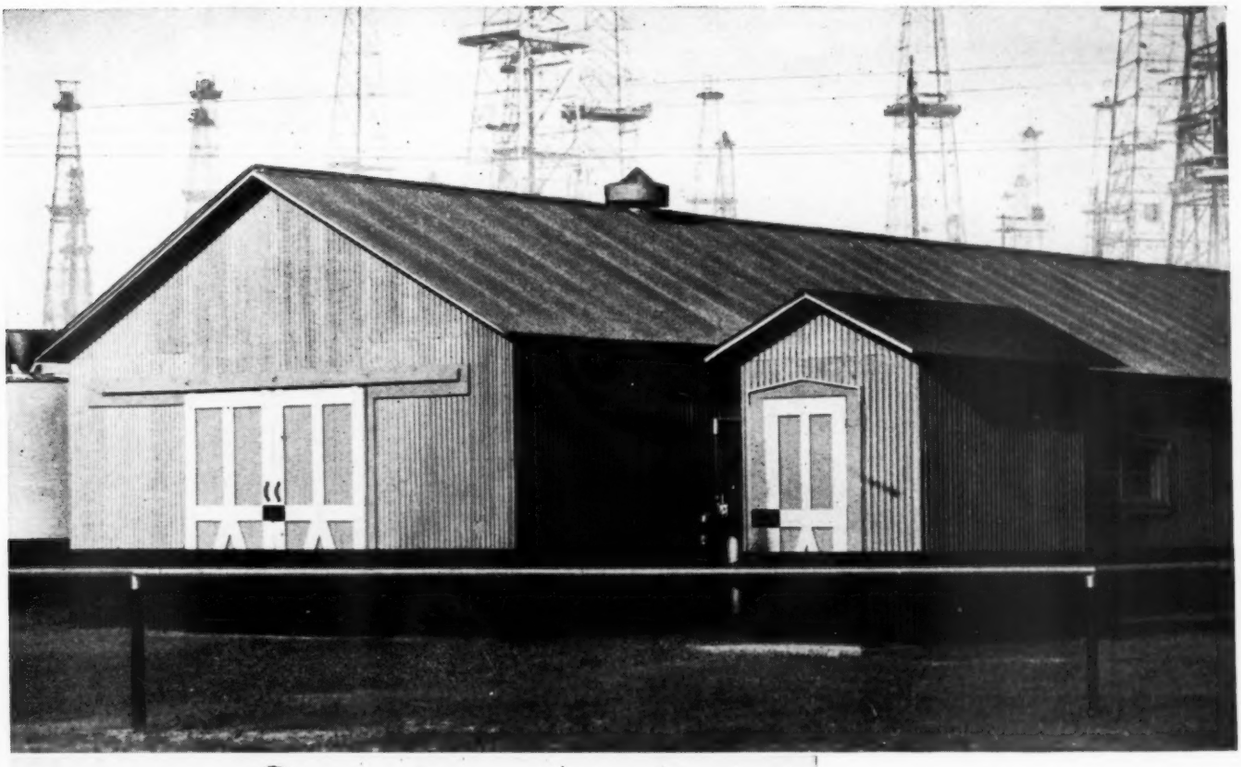
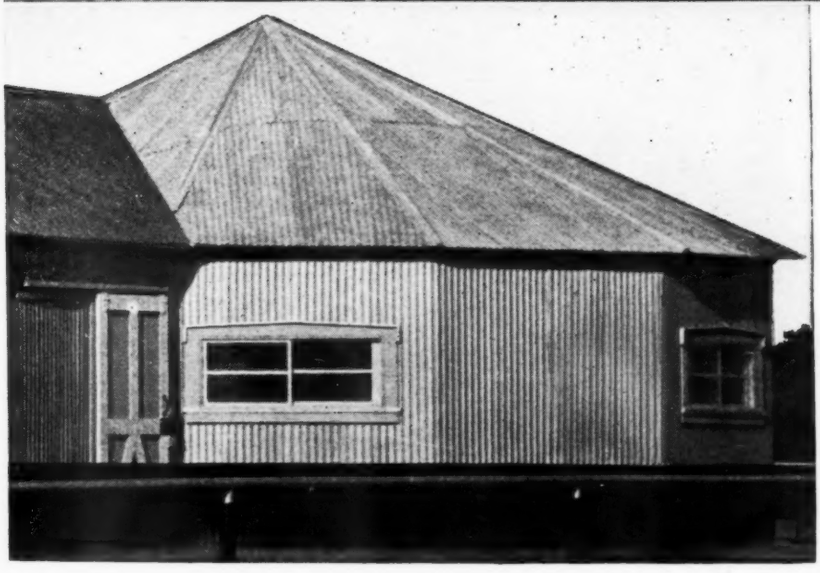
GO UP *Easily*–STAY UP *Long*





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90% of the wells
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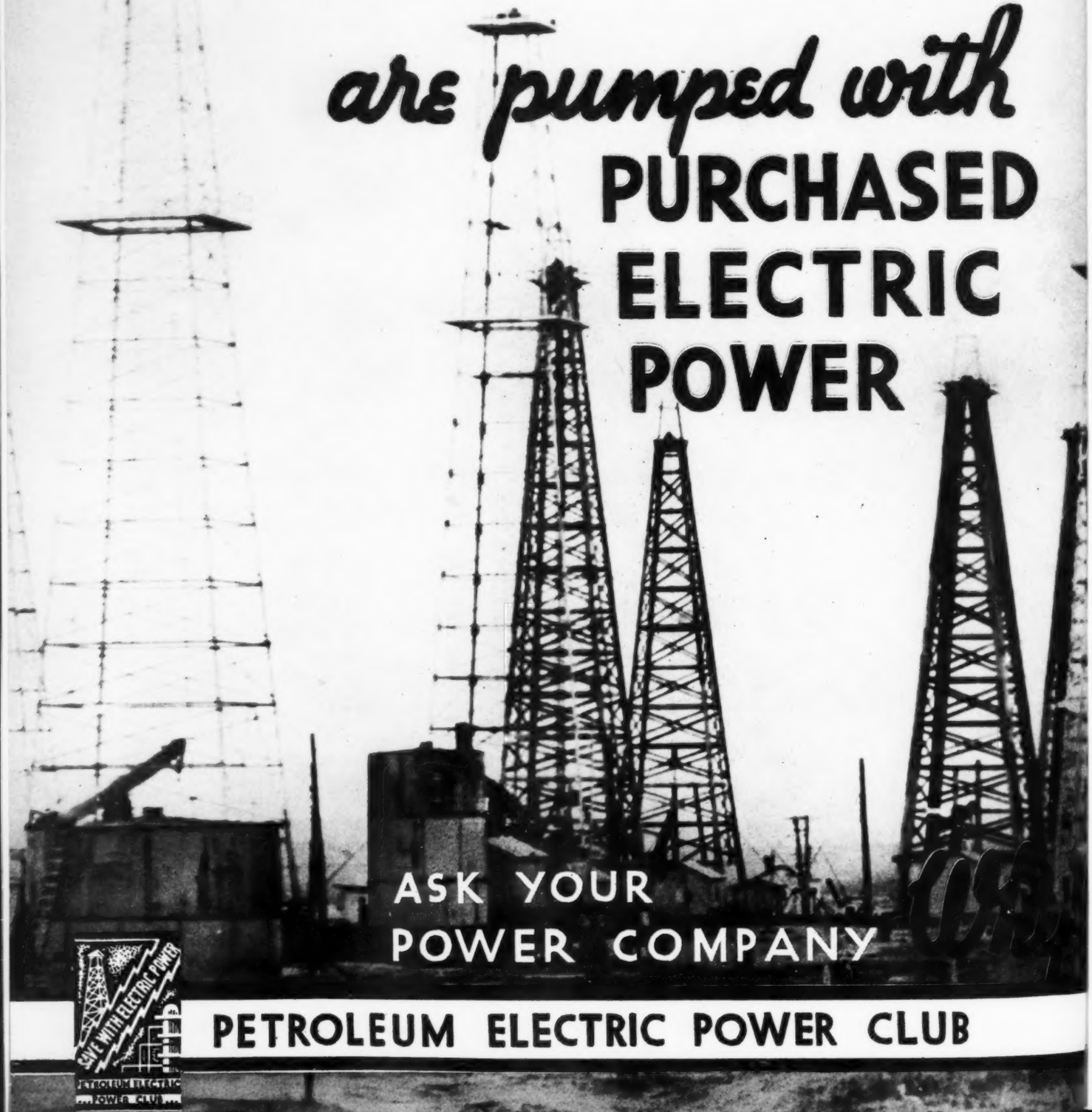
are pumped with
PURCHASED ELECTRIC POWER



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SAVE WITH ELECTRIC POWER
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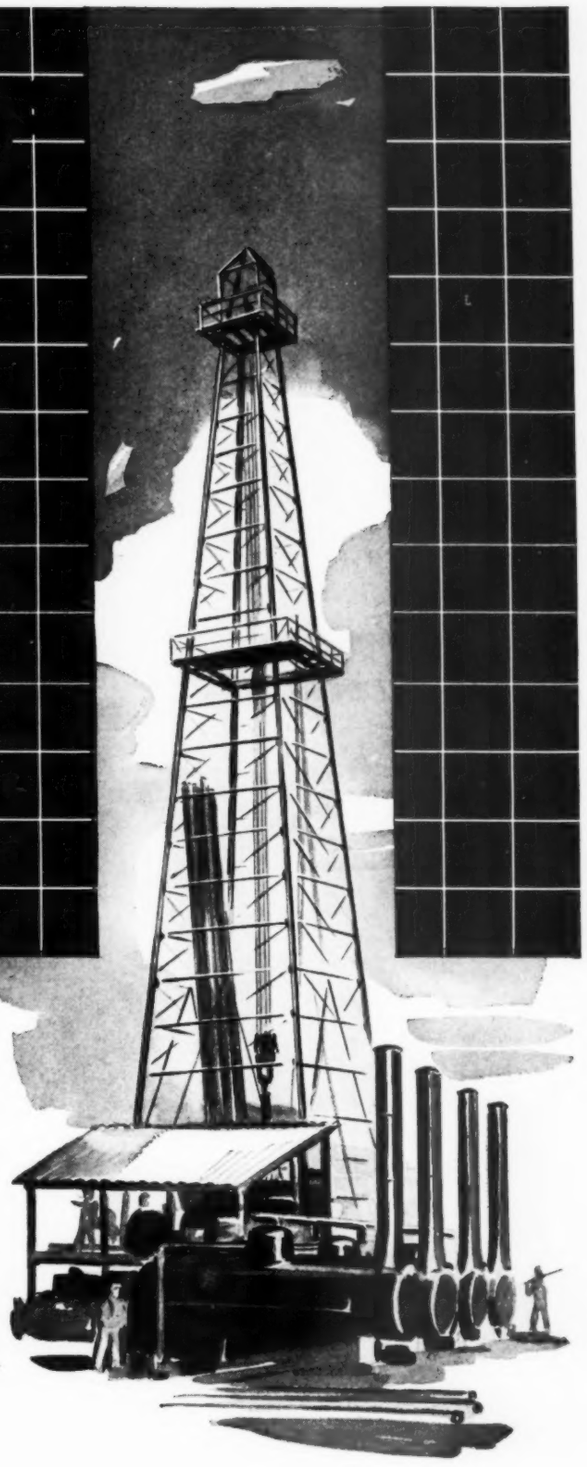
In

OIL FIELD PERFORMANCES



REPUBLIC ALLOY STEELS are constantly helping to set new standards of performance.

Bits of Republic's Agathon Alloy Steels were used in rotary drilling the world's deepest oil well . . . 12,786 feet.

A check-up of a recently published list of the thirteen deepest oil wells in the world showed that Republic's Alloy Steels were used for the bits in all thirteen jobs.

Through the specialized study of its metallurgists, Republic, world's largest producer of alloy steels, is equipped to interpret oil production problems and to help you set new performance records with Agathon Alloy Steels in sucker rods, rotary drilling bits, drill collars, reamer bodies, swivels, wire rope, chains, tool joints and other applications. The experience and counsel of Republic's Metallurgists are at your disposal. Write Department PT.

REPUBLIC STEEL

Republic Steel

CORPORATION

ALLOY STEEL DIVISION, MASSILLON, OHIO

GENERAL OFFICES: CLEVELAND, OHIO

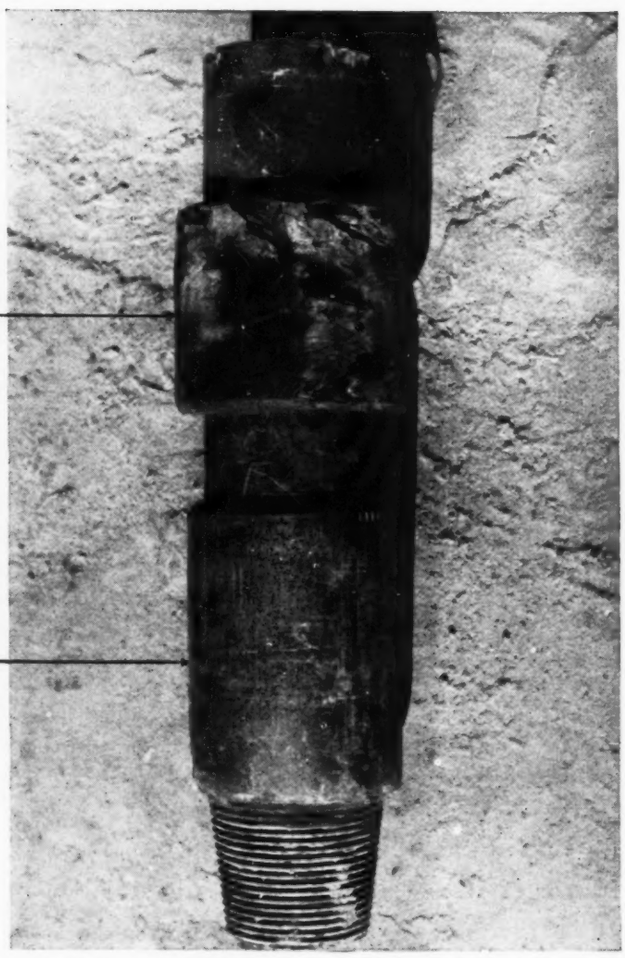
When writing Republic Steel Corporation for further information, please address Department PT

"after 4 years of very tough drilling service the tool marks still show"

In a pipe yard at Kettleman Hills this photograph was taken. It shows a 6-in. extra long Patterson-Ballagh Protector which was in constant drilling service for four long years, operating under the severest drilling conditions. Note the original factory tool marks on the drill collar. It proves minimum of abrasion. It proves the extra life given to drill pipe when equipped with Patterson-Ballagh Protectors.

If you want to lower your drilling costs the surest way is to install Patterson-Ballagh Protectors.

Fresh stocks warehoused in principal drilling fields



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ALL-RUBBER PROTECTORS THE ORIGINAL

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CONTINENTAL EMSCO CO., INC., 30 Rockefeller Plaza, New York City
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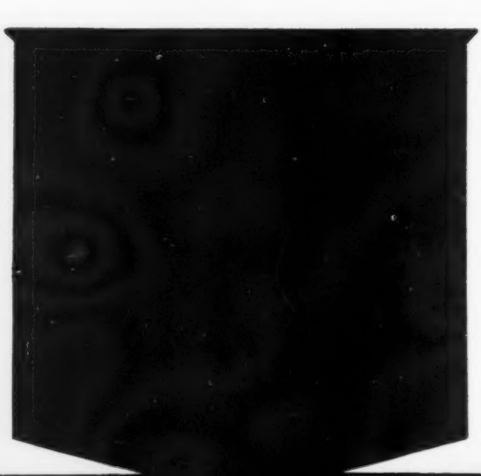
It wont be Long now

9th INTERNATIONAL PETROLEUM EXPOSITION

TULSA May 16-23, 1936



The International Petroleum Exposition officers, management and staff announce completion of all arrangements for the "World's Fair of the Oil Industry," which this year will break all previous records for number and size of exhibits, amount of exhibit space sold and variety of improvements in equipment, methods and materials for the oil industry.

See the vast display of heavy drilling and production equipment in actual operation, and the largest and most complete marketing division. Meetings, displays and demonstrations by societies, associations, bureaus and departments serving the petroleum industry add to the scientific, technical and educational value of the big oil show.

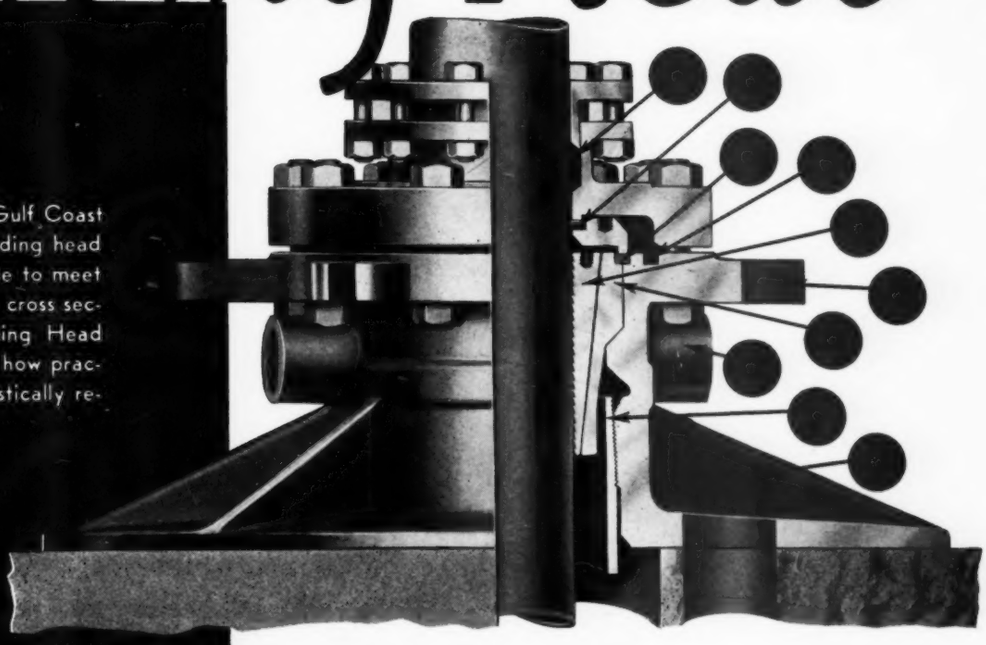
The Exposition will be ready in every detail on the opening day. It won't be long now. Will you be there?

Phone, write or wire for complete information, to—

WM. B. WAY, General Manager
Phone 6-2171 — Tulsa, Oklahoma — U. S. A.

The World's Fair of the Oil Industry

Examine Every Feature of this BAASH-ROSS Landing Head



This is the landing head that Gulf Coast operators demanded—the ONE landing head that is especially designed and made to meet Gulf Coast conditions. Examine the cross section view of the Baash-Ross Landing Head point by point—you will readily see how practical it is, and why it is so enthusiastically received by modern operators.

The wide landing base, integral with th body of the Baash-Ross Type "C" Landing Head, supports the outer casing and provides a solid, rigid foundation for the Baash-Ross Blowout Preventer during drilling for the oil string. The passage through the body is as large as the inside diameter of outer casing.

The Baash-Ross Landing Head is economical to buy, and it enables the operator to make savings all along the line. Its compactness eliminates the necessity of digging a deep cellar or raising the derrick floor. Casing clamps and complicated tie-down equipment are done away with.

When the oil string is cemented, the desired stretch is taken in the pipe and the slips are set. From then on the oil string is rigidly supported independently of the outer string.

These Landing Heads are made in the sizes required for all Gulf Coast casing programs. Stocked at Houston ready for immediate delivery to your job.

HERE ARE THE *Advantages* OF THE BAASH-ROSS LANDING HEAD . . .

1-2 Double packing around the oil string assures greater safety under high pressure. Both the hydraulic packing and the lead gasket can be tightened at any time without disturbing connections.

3 Lead gasket which packs off the outer string of casing is compressed by means of packing ring simultaneously with the gasket around the oil string when flange bolts are tightened.

4 Groove for lead gasket to seal off joint between drilling flange and blowout preventer.

5 Three piece interlocked slips support oil string safely.

6 Slotted ears for tie down rods are integral with body.

7 Spiders and slips made in all sizes to accommodate any size oil string desired.

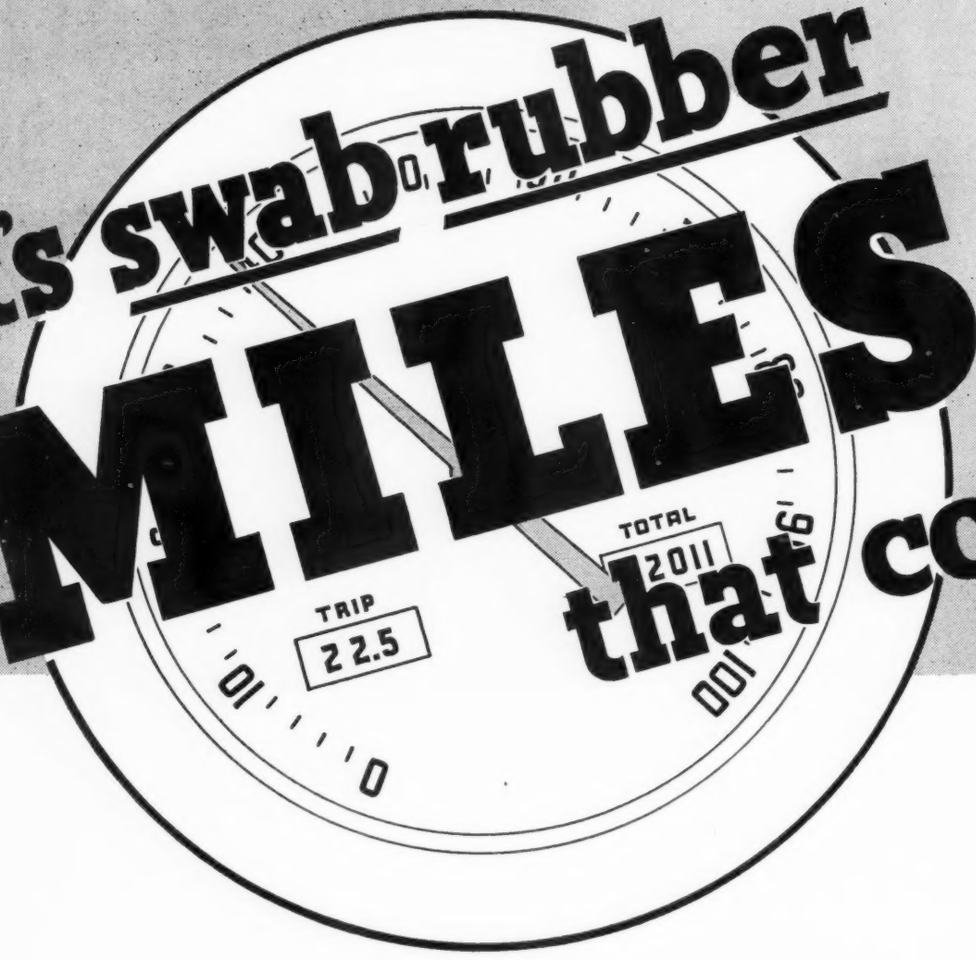
8 Two 2" side outlets, 180° apart, are standard. Larger outlets available on order.

9 Connection of outer string to landing base may be as desired—threaded, welded or both.

10 Strongly ribbed landing base furnishes solid support for outer string while drilling for oil string.

Export Office
NEW YORK, N.Y., U.S.A.
NORRIS-WOOD SUPPLY CO.

It's swab rubber MILES that count!



Experience Shows that the Rubbers on TYLER SWABS Last Longer

Simplicity of design insures proper rubber adjustment, compensating for wear.

Reversible rubbers give longer life.

Rubbers automatically expand by hydraulic action.

Minimum of friction going into the hole.

The largest possible by-pass area permits free falling.

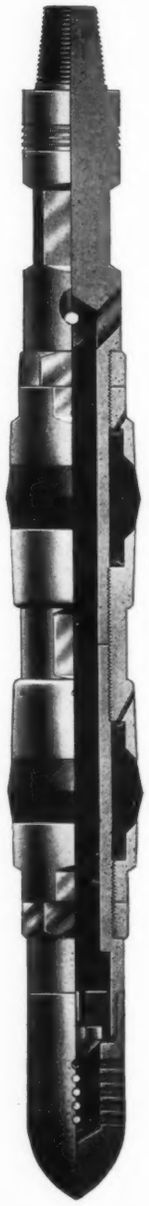
Ease of part replacement means lower upkeep.

Reversible valve permits down swabbing.

Rubbers of different hardness and elasticity are furnished to fit different well conditions.

Let us tell you how this rubber stays young.

Engineering data and prices on request.



THE TYLER SWAB
(Patented)

M·O·JOHNSTON OIL TOOLS INC.

3117 San Fernando Road • Los Angeles, Calif.
Phone Albany 0186

Mid-Continent Distributor: J. L. JOHNSTON

1530 Bonnie Brae • • Houston, Texas

THE Petroleum Engineer

APRIL 1936

VOLUME VII NUMBER VII

A MAGAZINE OF METHODS FOR OPERATING MEN

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Meetings

Oil Equipment and Engineering Exposition—April 20, 21, 22, 23, 24, and 25, Houston, Texas.

California Natural Gasoline Association—May 7, Richfield Building, Los Angeles.

American Gas Association, Natural Gas Department — May 5, 6, 7, and 8, Baker and Adolphus Hotels, Dallas, Texas.

Natural Gasoline Association of America, Annual Meeting—May 13, 14, and 15, Mayo Hotel, Tulsa, Oklahoma.

American Petroleum Institute, Mid-Year Meeting—May 13, 14, and 15, Tulsa, Oklahoma.

International Petroleum Exposition —May 16-23, Tulsa, Oklahoma.

Independent Petroleum Association of America, Mid-Year Meeting—May 21, Tulsa, Oklahoma.

National Stripper Well Association, Annual Meeting—May 22, Tulsa Oklahoma.

American Society of Mechanical Engineers, Semi-Annual Meeting—June 15, 16, 17, 18, 19, and 20, Dallas, Texas.

Pennsylvania Grade Crude Oil Association, Annual Meeting—June 18 and 19, State College, Pennsylvania.

American Society for Testing Materials, Annual Meeting—June 29 to July 3, Chalfonte-Haddon Hall, Atlantic City, New Jersey.

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By K. C. SCLATER

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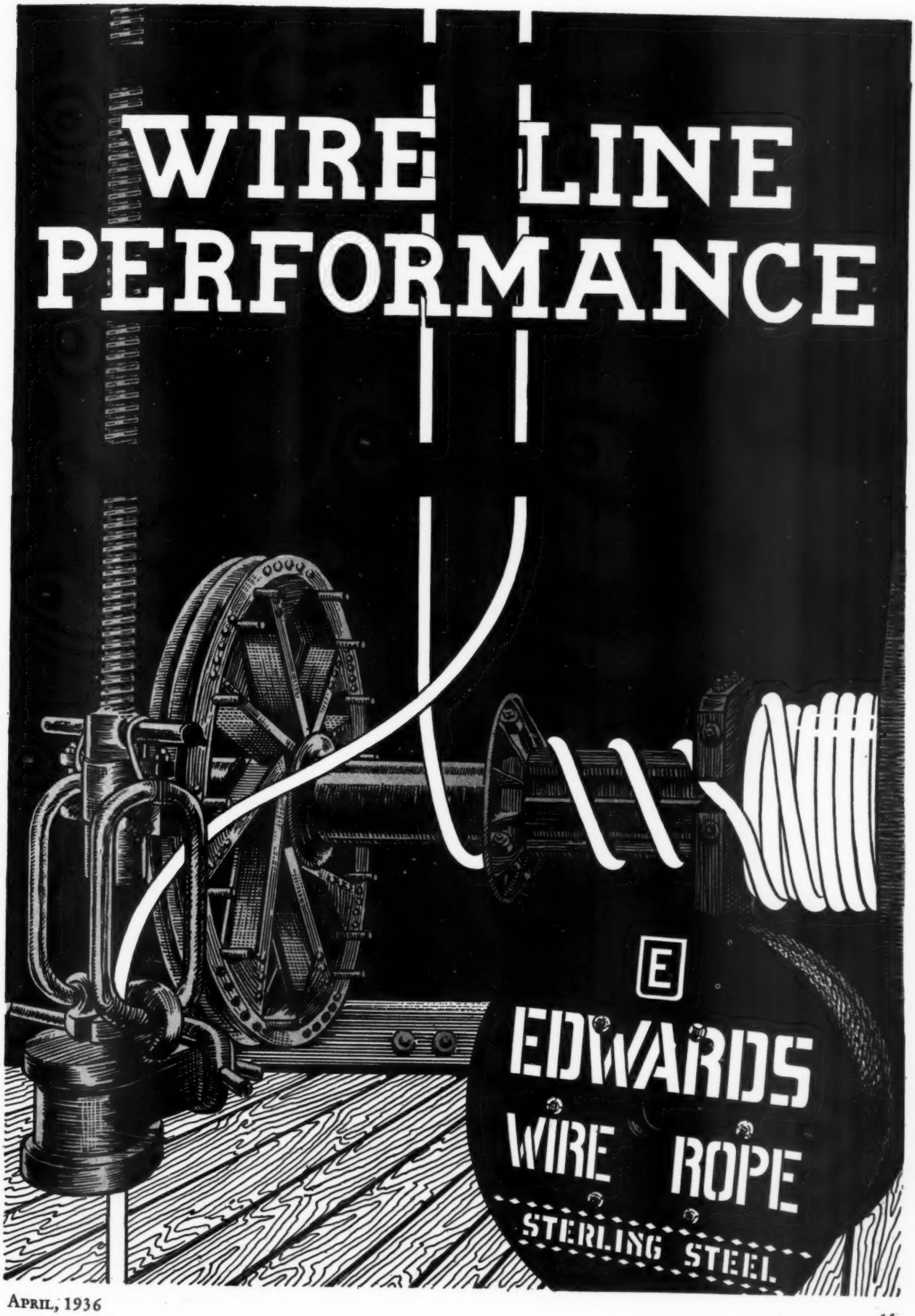
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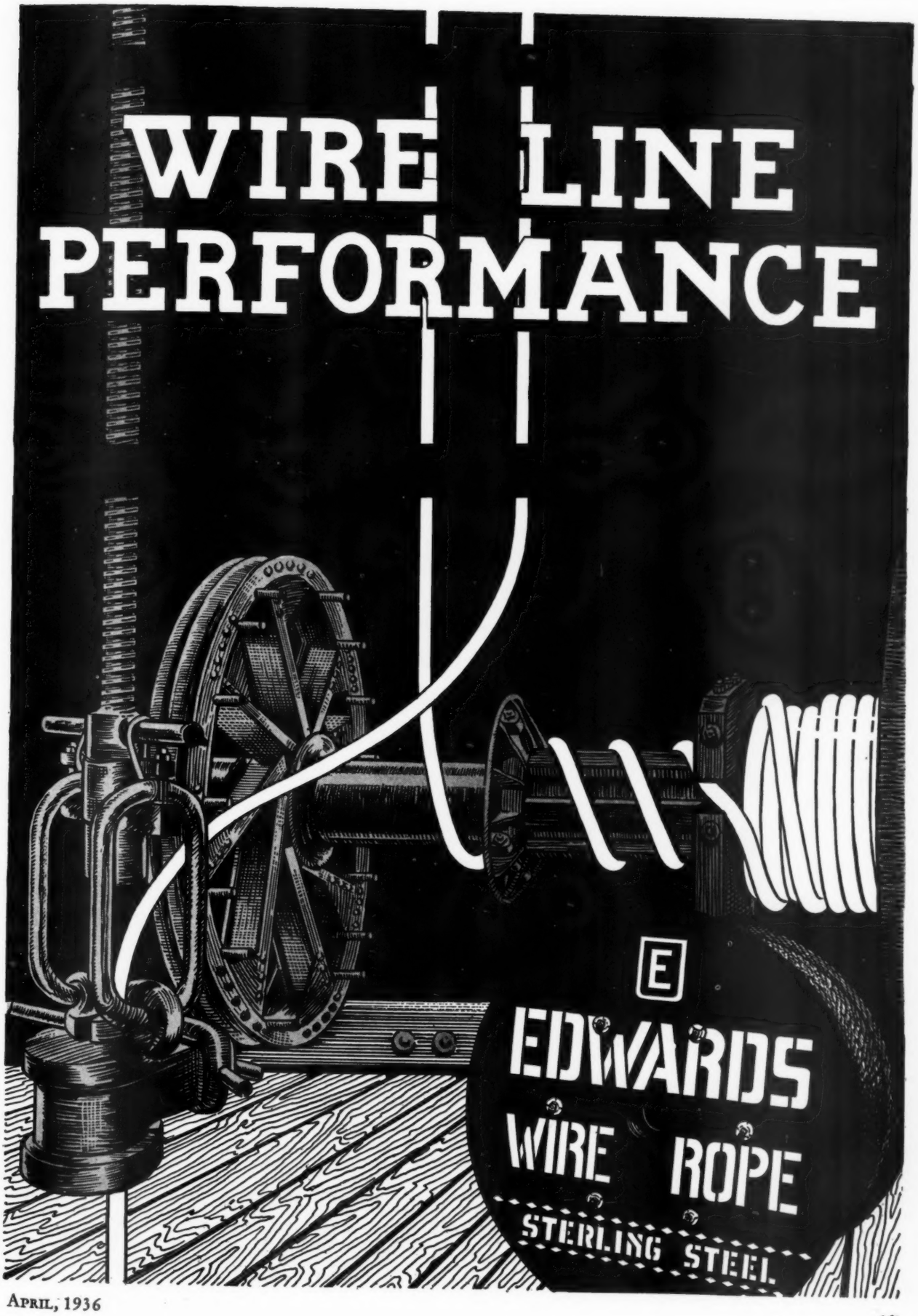
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PROGRESS OF MAJOR PIPE LINE WORK

CONSTRUCTION work will start in the near future on a 230-mile 22-in. natural gas line from Zionsville, Indiana, near Indianapolis, to Detroit, Michigan. It is expected to be completed and in operation by July 1st. This is the largest gas line project announced for 1936, and the largest for several years. Contracts making the work possible have been signed by Gano Dunn, trustee appointed by the Chancery Court of Delaware in the decree involving the Panhandle Eastern Pipe Line Company, Columbia Gas and Electric Corporation, and the Columbia Oil and Gasoline Company. The project also includes considerable work on the Panhandle Eastern line.

The line will be constructed for the Michigan Gas Transmission Company, subsidiary of the Columbia Gas and Electric Corporation, and will tie into the Panhandle Eastern's line at Zionsville.

The W. S. Bibb Contracting Company, Kansas City, Missouri, has been awarded the contract for the laying of 160 miles of the line, all of that in the state of Indiana. As required by state law, the Michigan portion of the line will be constructed by a Michigan contractor not yet named. H. C. Price, Inc., Bartlesville, Oklahoma, has been given a contract for electric welding 172 miles of the line.

The National Tube Company has been given a $3,500,000 order for 22-in. seamless pipe, 44,000 tons being required. A large portion of this pipe will be made at the Lorain Works of the National Tube Company at Lorain, Ohio, and also at the National Works at McKeesport, Pennsylvania.

The Cooper-Bessemer Corporation has been awarded a contract for 14 twin-tandem gas-engine-driven compressor units, the largest order since 1930 for equipment of this kind. It calls for 12 1300-hp. units and two 1000-hp. units.

The Panhandle Eastern is one of the longest natural gas lines in the world. It was constructed in 1930 and equipped with Cooper-Bessemer engines and compressors. The present system extends a distance of 1350 miles between western Texas and Zanesville. This carrier will supply gas to the new line to be laid by the Michigan Gas Transmission Company. The major part of the machining and assemblying of the units will be done at the Cooper-Bessemer plant in Mount Vernon, Ohio.

From the Worthington Pump and Machinery Company have been ordered eight 24 by 36 twin-tandem gas-engine compressor units of 1300-hp. each.

●

A new 10-in. oil line, to extend from the Kettleman Hills field of California to Estero in San Luis Obispo County, is to be constructed by the Seaboard Oil Company and The Texas Company. For the purpose a new company will be organized known as the Valley Pipe Line Company. The right-of-way will be along the same general route as that followed by the Standard Oil Company in laying its two lines from Kettleman Hills. Construction work is expected to commence July 1st, with the line in operation before the end of the year. It will be approximately 80-miles in length.

Two pumping stations will be erected, and at Estero four steel tanks, each having a capacity of 118,000 bbl., will be provided. Approximately 2500 ft. submarine line will be provided for the loading of tankers.

The Stanolind Pipe Line Company has awarded a contract to O. C. Whitaker, Inc., of Burkburnett, Texas, to lay 31-miles of 8-in. pipe to loop the two existing 8-in. lines between their main pump station in the Fitts field of Pontotoc County, Oklahoma, and a point near Pauls Valley. The new loop will increase the Stanolind's present capacity of 40,000 bbl. daily by approximately 10,000 barrels. The pipe being laid is reconditioned stock taken from other portions of the company's system.

The Stanolind also has moved its field station McKoy B to section 27-2-7e, approximately four miles east of the main pumping station, in order to improve its gathering service.

Additional work in the area on the part of the Stanolind is the increasing of the capacity of the Tribbey, Oklahoma, station by the installation of a 440-hp. Diesel engine driving a slow-speed horizontal pump.

●

The White Eagle Division of the Socony Vacuum Oil Company, is laying a 6-in. loop to its line from the Burrton area of Reno County, Kansas, to Valley Center, a distance of 26 miles, to increase capacity. H. W. Knupp and Sons, Newton, Kansas, are the contractors.

●

The Derby Oil Company, Wichita, Kansas, has under consideration the laying of a 4-in. gasoline line from the Burrton pool of Reno County, Kansas, to its refinery at Wichita. At present gasoline and other products refined at the Wichita plant are transported to Bell Station by tank car, and from there boosted to the McPherson terminal by pipe line.

●

The Northern Natural Gas Company has awarded a contract to the Truman-Smith Construction Company of Eldorado, Kansas, for the laying of a 20-in. gas line from the Hugoton field of Kansas to Mullinville, a distance of 100 miles. The A. O. Smith Corporation will supply the pipe.

●

The Magnolia Pipe Line Company has added 26½ miles to its Oklahoma system, extending its line from the Maud station to the Fitts field. The new line is of 8-in. pipe. In addition, an extensive gathering system has been constructed, and two 55,000-bbl. steel tanks erected at the Fitts field booster station.

●

The Gulf Refining Company has completed its 57½-mile 8-in. trunk line extension from Hendrick station, Winkler County, Texas, to the Monument area, Lea County, New Mexico. An eight mile 6-in. extension also has been laid to the Hobbs field, as well as laterals to the Monument and Eunice fields.

●

The Shell Pipe Line Company is now pumping oil through its new 10-in. line connecting Hobbs, Eunice, Jal, Monument, and other fields of southeastern New Mexico, with its main line in Winkler County, West Texas.

BULL PLUGS and SWAGED NIPPLES

FULL STOCKS are carried at all "OILWELL" Stores

Any size. Any thread.

Made of new "National" Seamless pipe.

Branch Stores in all Oil Fields

OIL WELL SUPPLY CO.

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3437

"OILWELL"

LATEST ACTIVITIES IN THE OIL FIELDS

A NEW oil field has been discovered in the Corpus Christi area, San Patricio County, Texas. Benedum and Trees successfully completed their No. 2 E. H. Welder at a total depth of 5710 feet. The well is three and one-half miles northeast of Sinton and west of the Plymouth field, and is producing from the Frio formation.

●

One mile southeast of Santa Maria, Santa Barbara County, California, the Union Oil Company has completed its No. 1 Adams for an estimated 3500 bbl. per day of 15.4 gravity oil. This apparently marks the opening of a new field. The well was drilled to a total depth of 2576 feet.

●

With the completion as a producer of No. 1-A Bird, T. T. Eason, Amerada Petroleum Corporation, and the Stanolind Oil and Gas Company have given Logan County, Oklahoma, its ninth oil pool. The latest pool will be known as the West Lovell. The well is producing from the Wilcox sand at 6130-6145 feet. On the initial test it flowed 44 bbl. the first hour through casing, 48 bbl. the second hour through tubing, 63 bbl. the third hour through casing, with the gas measuring 35,750,000 cu. feet. Then for three hours it was allowed to flow through casing, producing 73 bbl. the first, 67 bbl. the second, and 64 bbl. the third, with the gas volume increasing to 39,000,000 cu. feet.

●

No. 3 Government, brought in by the Kinney-Coastal Oil Company in Big Horn County, gives Wyoming a new field. This is an outpost well on the Garland Dome. It is producing from the Tensleep sand at a total depth of 4338 ft., making 50 bbl. of crude and 3,400,000 cu. ft. of gas daily initially. With the successful completion of this well several thousand acres are being tested in the Garland area for the Tensleep oil zone.

●

Two new pools have been discovered in Russell County, Kansas. Approximately nine miles south of the town of Russell and a mile northeast of the Gideon pool, Charles Newbold et al have completed their No. 1 Krug at a total depth of 3220 ft., penetrating the Arbuckle lime a distance of two feet. The hole filled up 600 ft. in four hours.

Between the Ochs and Rude pools the Coralena Oil Company brought in its No. 1 Trapp pumping 1231 bbl. per day from the Arbuckle lime. The well was drilled to 3253 ft., penetrating the producing formation but one foot.

●

A new Central Michigan field halfway between Crystal and Porter seems apparent with the discovery of oil by the Mountain Oil and Gas Company with their No. 1 Walters test in Gratiot County. Production was found in the Dundee lime at 3250 feet. The strike caused considerable excitement and is being looked upon as possibly the greatest discovery of the year for Michigan.

●

The bringing in by the William E. Hughes Estate of its No. 5 Gramps in the Price district, Archuleta County, Colorado, opens a new field, and is considered a discovery of major importance. The well, drilled to a total depth of 1100 ft., is producing from the second Dakota formation, with its production estimated at 1800 to 2200 bbl. daily of 32.3 gravity oil.

●

A new oil-producing area has been given eastern Lea County, New Mexico, by the Barnsdall Oil Company. Five and one-half miles east of the original Eunice field and five miles northwest of the South Eunice field, that company has brought in its No. 1 Hardy. At a depth of 3774 ft. the well flowed by heads, and the owners intended to deepen to 3800 feet.

●

A second producing well has been brought in in the Talco area of northeast Texas by the Humble Oil and Refining Company with their No. 1 A. P. King-Hughes. The well flowed 500 bbl. per day at a total depth of 4197 ft. on the initial test.

AVERAGE CRUDE PRICES

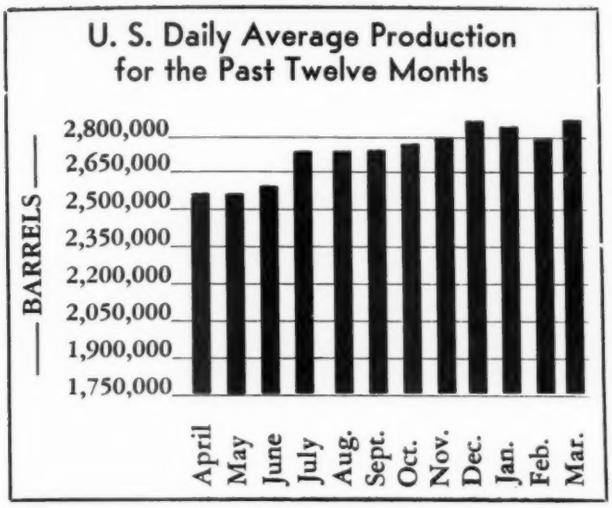
California	
Kettleman Hills	$1.22-$1.43
Playa Del Rey	1.10
Coalinga	.70-.90
Signal Hill	1.10
Montana	1.45
Wyoming	1.10
Colorado	1.00-1.10
New Mexico	.75-.95
Texas	
North Central	.84-1.08
Panhandle	.81-.98
West Texas	.75-.95
Gulf Coast	.85-1.30
Darst Creek	.88-1.22
East Texas	1.15
Kansas	1.10
Oklahoma	1.10
Arkansas	.75-.80
Louisiana	
North Louisiana	$ .86-$1.10
Gulf Coast	.82-1.22
Illinois	1.23
Kentucky	1.23
Indiana	1.12
Ohio	
Lima	1.25
Michigan	1.12
Pennsylvania	
Bradford	2.45
Southwest	2.17
Eureka	2.12
Buckeye	1.97
Corning	1.42
West Virginia	1.67
Canada	2.10-2.17

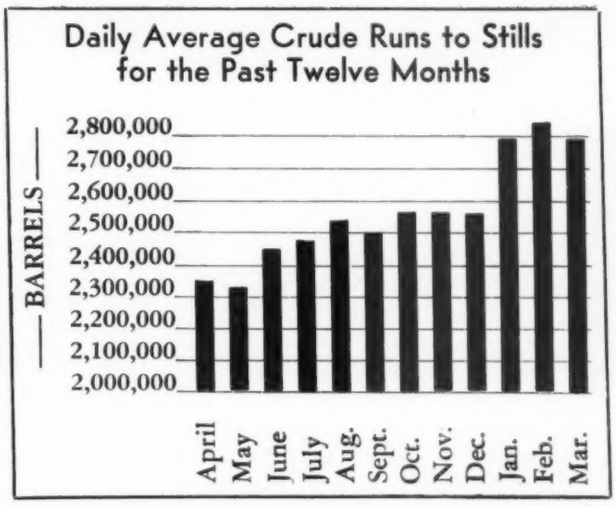
DAILY AVERAGE CRUDE OIL PRODUCTION

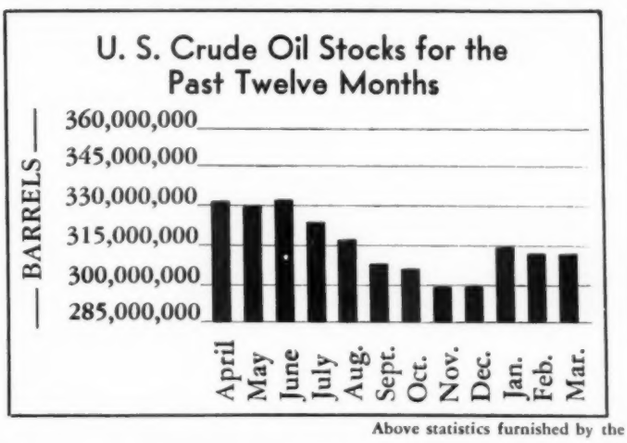
Supplied by A.P.I.

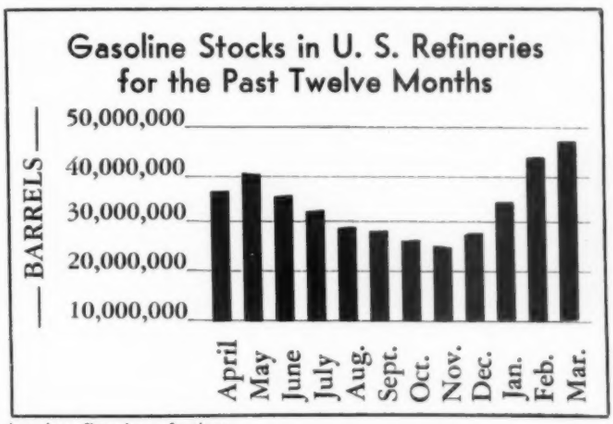
Figures in Barrels

	B. of M. Dept. of Interior Calculations (March)	Week Ended March 28, 1936	Week Ended Feb. 29, 1936	Week Ended March 30, 1935
Oklahoma	506,300	546,050	499,500	492,650
Kansas	142,000	159,600	149,650	154,900
Panhandle Texas	.....	63,100	60,450	73,000
North Texas	.....	57,600	56,600	57,700
West Central Texas	.....	25,050	24,800	25,750
West Texas	.....	176,050	162,200	153,500
East Central Texas	.....	49,900	48,600	51,400
East Texas	.....	442,600	436,600	448,850
Southwest Texas	.....	74,000	70,750	60,200
Coastal Texas	.....	230,600	220,150	182,050
TOTAL TEXAS	1,104,000	1,118,900	1,080,150	1,052,450
North Louisiana	.....	65,450	66,200	22,900
Coastal Louisiana	.....	137,650	133,750	96,500
TOTAL LOUISIANA	151,400	203,100	199,950	119,400
Arkansas	31,900	29,700	29,550	30,600
Eastern	105,100	103,250	107,950	108,850
Michigan	44,300	37,750	37,300	37,700
Wyoming	34,800	35,650	32,150	32,950
Montana	12,400	13,300	12,400	10,700
Colorado	3,700	4,350	4,000	5,100
New Mexico	64,200	60,850	57,100	47,050
TOTAL EAST OF CALIF.	2,200,100	2,312,500	2,209,700	2,092,350
California	538,800	563,700	565,000	470,900
TOTAL U. S.	2,738,900	2,876,200	2,774,700	2,563,250









Above statistics furnished by the American Petroleum Institute.

Summarized Operations in Active Fields for March, 1936

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	223	212	84	135	3600	2	40	Rotary
Duval County	98	88	16	33	2300	2	22	Rotary
Archer County	49	22	14	31	660–1800	1 or 2	40	Rot.-Cab.
Conroe	3	3	1	1	2000–7400	3 or 4	40	Rotary
Panhandle	50	47	33	146	2200–3900	2	40	Rotary
Refugio County	4	4	1	3	5200	2	38	Rotary
OKLAHOMA								
Oklahoma City	9	6	15	64	6500	3	39	Rotary
Pontotoc County	38	34	15	86	1800–4488	2 or 3	38	Rotary
Osage County	21	16	14	41	380–2850	2	37.5–40	Rot.-Cab.
KANSAS								
McPherson County	2	2	2	6	2900–4300	2	38	Rot.-Cab.
Harvey County	5	2	2	2	3450	2 or 4	37	Rot.-Cab.
Ellsworth	70	59	35	122	3300	4	37	Rot.-Cab.
LOUISIANA								
Rodessa	29	29	10	59	5985–6450	3	39	Rotary
CALIFORNIA								
Kettleman Hills	7	6	10	26	8300	3 or 4	40	Rotary
Long Beach	0	0	1	6	7000	3	36	Rotary

Field Activities by States for March, 1936

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1935 (In Barrels)
	March	February	March	February	March	February	March	February	March	February	
Arkansas	8	4	2	3	6	5	9	11	33	31	11,140,750
California	59	62	52	53	62	67	85	83	209	203	207,899,480
Colorado	3	....	1	....	....	....	3	4	23	26	1,565,150
Illinois	4	2	4	1	....	....	20	21	6	5	4,352,000
Indiana	29	9	14	3	....	....	3	2	64	61	762,000
Kansas	122	83	96	58	131	121	51	49	274	267	53,013,450
Kentucky	13	21	10	11	....	....	4	3	14	13	4,860,000
Louisiana	85	55	67	45	113	98	59	52	196	175	50,299,950
Michigan	49	35	35	24	48	39	79	80	118	117	15,661,350
Mississippi	....	1	....	0	....	....	1	1	9	10	Gas. Prod.
Montana	3	6	2	5	....	....	9	10	57	55	4,304,100
New Mexico	39	40	38	37	....	....	14	12	111	107	19,195,500
New York	....	....	....	....	....	....	1	2	2	3	3,191,900
Ohio	117	229	81	179	....	....	39	33	169	161	4,234,000
Oklahoma	194	162	139	129	228	184	69	64	556	527	181,152,050
Pennsylvania	....	....	....	....	....	....	12	13	106	108	14,478,000
Texas	935	757	719	596	1170	1104	512	452	1442	1262	377,747,205
West Virginia	24	52	22	42	....	....	32	30	116	113	3,818,400
Wyoming	4	2	3	2	....	....	7	8	64	61	13,320,100
Totals	1688	1518	1285	1187	1718	1618	1009	910	3569	3300	970,995,385

THE MONTH'S ACTIVITIES IN REFINING

Percent Refinery Capacity Operated

Western Division, 68.2 percent **Central Division, 69.1** **Eastern Division, 72.5 percent**

THE 2000-bbl. capacity refinery constructed by the Park Refining Company at Cody, Wyoming, is now operating. Oregon Basin crude is being processed, and road oil, fuel oil, and gasoline are being manufactured. Valentine M. Kirk is president of the Park Refining Company. C. W. Hart had charge of the construction of the plant and is operating superintendent.

●

The Continental Oil Company has contracted to Petroleum Engineering, Inc., Tulsa, Oklahoma, associated with Arthur G. McKee and Company, a complete gasoline recovery and crude oil stabilization plant to be erected on their Tepetate holdings near Eunice, Louisiana. The plant is to process 50,000,000 cu. ft. of gas daily at a pressure of 300 lb. to 500 lb., and to stabilize the high-gravity crude to a 42 gravity for shipment to the Continental refineries.

●

Nead Oil Refineries, Ltd., have purchased property at Owen Sound, Ontario, Canada, to be used as a site for the erection of a 750-bbl. Dubbs cracking plant. Storage tanks also will be provided. A. J. Dean is president of the organization.

●

The Parade Gasoline Company is adding equipment to increase the capacity of its plant near Turnertown in the East Texas field, and is extending its gathering system to connect with approximately 300 additional wells. Natural gasoline and butane are manufactured and with the new equipment the capacity of the plant will be 15,000,000 cu. ft. of gas daily.

●

A refinery is being constructed at Dyer, Ohio, by the H. A. Montgomery Company of Detroit, Michigan, for the manufacture of naphthas, mineral spirits, light fuel oil, kerosene, high-grade neutrals, and residuals. No gasoline will be produced. Russell Crothers, chief engineer, is in charge of the construction work.

●

Leonard Refineries, Inc., recently incorporated under the laws of Michigan, have erected a refinery at Alma having 3500 bbl. daily capacity. A Dubbs cracking unit with a capacity of 1500 bbl. daily has been installed. Crude supply is from the Crystal field.

●

The Onyx Refining Company is installing cracking equipment at its 800-bbl. refinery at Abilene, Texas.

●

The natural gasoline absorption plant of the Pelican Oil and Gasoline Company in the Rodessa field of Louisiana is expected to be completed by the latter part of April. The capacity of the plant will be 50,000,000 cu. ft. daily, and approximately 80,000 gal. of gasoline will be produced daily. The Frick-Reid Supply Corporation of Tulsa, Oklahoma has the general contract for the construction of the plant, with erection by Mattison-Wallack and Company of Oklahoma City.

●

The British-American Oil Company has a natural gasoline absorption plant under construction in South Turner Valley, Alberta, Canada. It will be completed by the latter part of May. The capacity of the plant will be 60,000,000 cu. ft.

●

The East Texas Refining Company has placed in operation a new natural gasoline plant of the absorption type in the Rodessa field of Louisiana. The plant has a capacity of 10,000,000 cu. ft. of gas daily, and was designed by the Ampco Engineering Company, Dallas, Texas. A feature of the plant is its fired reboilers, gas being used as the fuel.

●

McColl-Frontenac Oil Company, Ltd., has arranged with The Gray Processes Corporation for a substantial increase in its licensed Gray "Clay Treating" capacity. Part of the increase represents increased throughput of existing equipment, while the rest was arranged in order to take care of the production of cracked and reformed gasoline expected as a result of proposed additions to the existing cracking equipment. McColl-Frontenac use Gray towers in both their Toronto and Montreal refineries.

Quaker State Oil Refining Corporation has resumed Gray "Clay Treating of its house brand gasoline marketed under the "Sterling" trade mark. The Gray towers are directly connected to Dubbs cracking units.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks
Week Ended March 28, 1936
A.P.I. Figures
(Figures in Barrels of 42 Gallons Each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	500,000	81.7	18,956	6,248
Appalachian	94.8	76,000	52.1	2,915	530
Ind., Ill., Ky.	95.9	355,000	83.7	11,495	2,794
Okla., Kans., Mo.	84.8	255,000	66.4	7,902	2,547
Inland Texas	48.5	91,000	56.9	1,876	1,429
Texas Gulf	96.8	587,000	89.2	9,035	6,638
La. Gulf	96.4	122,000	74.8	1,927	2,131
No. La.-Ark.	90.0	42,000	58.3	409	389
Rocky Mt.	61.9	44,000	73.3	1,595	696
California	92.6	499,000	63.2	13,337	70,974
Reported	89.6	2,571,000	74.1	69,447	94,376
Est'd. Unreported	.....	194,000	.....	3,565	1,633
*EST'D. TOTAL	.....	2,765,000	.....	73,012	96,009
U. S. Mar. 28, '36	.....	.....	.....	.....	.....
*EST'D. TOTAL	.....	2,815,000	.....	73,157	95,862
U. S. Mar. 21, '36	.....	.....	.....	.....	.....
U. S. B. of M. March, 1935	.....	2,472,000	.....	**66,290	**99,380

*Bureau of Mines basis currently estimated.
**As of March 31, 1935.

Cleaning the coupling and adjacent pipe with small electric-driven portable machine

Close-up of machine showing its application in cleaning and preparing leaky pipe-line couplings for welding

Supplementary Pipe Cleaning

Old Hand Method of Cleaning Coupling Recesses Being Superseded by Use of Small Portable Electric-Driven Machine

By GORDON N. SCOTT*

ALWAYS of interest to pipe line operators are methods of cleaning pipe. While the machines usually employed leave little to be desired, from the point of view of cost and efficiency many occasions arise where the use of the heavier machines is impractical or costly, or where supplementary cleaning is advisable. A good illustration is afforded in the cleaning of collars in screw lines and in cleaning deep pits in the pipe. Since it was definitely ascertained that crude oil sweating or leaking from collars caused accelerated corrosion, pipe line operators have been welding leaky collars.

Sweating collars have accounted for many pit-hole leaks that have resulted in costly damage charges and, of equal importance, have created extensive artificial "hot spots" by contaminating the backfill with oil. The accelerated corrosion resulting from leaky collars may cause a pit-hole, thus further contaminating the soil, which if not removed causes more leaks and an extension of the "hot spot."

Many companies have engaged in a program designed to dispense forever with this type of corrosion problem. These plans vary in detail, but aim primarily, by welding the collars from year to year, to convert a screw line to substantially a welded line. An application of a portable grinding tool, modified for pipe line work, has recently met with favor in the Mid-Continent for cleaning, preparatory to welding, deep pits, collars, and their recesses.

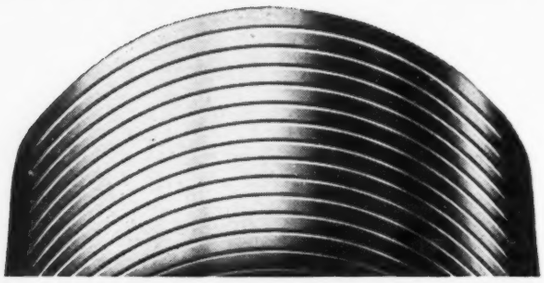
The unit consists primarily of a ¾-hp. electric motor and a 6-in. x 1-in. wire brush, coupled with a flexible shaft seven to nine ft. in length. The motor is operated at 3450 r.p.m. by a welding machine having an over-excitation of 1000 watts, such as is used for lighting when welding at night. To permit the welder and the brush operator freedom in movement over a wide range, the cable carrying the current from the welding machine may be 250 ft. or more in length. The cable must be of such current-carrying capacity as to prevent any appreciable drop in potential, thus assuring the operation of the brush at the correct speed.

The flexible shaft is of such length as to permit ample leeway for the brush to travel completely around a 10-in. collar. Some slight, and easily acquired, skill in operation is necessary, since the high speed tends to throw the revolving brush out of the workmen's hands. The brush guard prevents injury to the hands and also prevents fragmented strands of the brush from flying uncontrolled. A half-face enclosure on the guard would be more desirable for the latter purpose than the rim guard shown in the accompanying pictures.

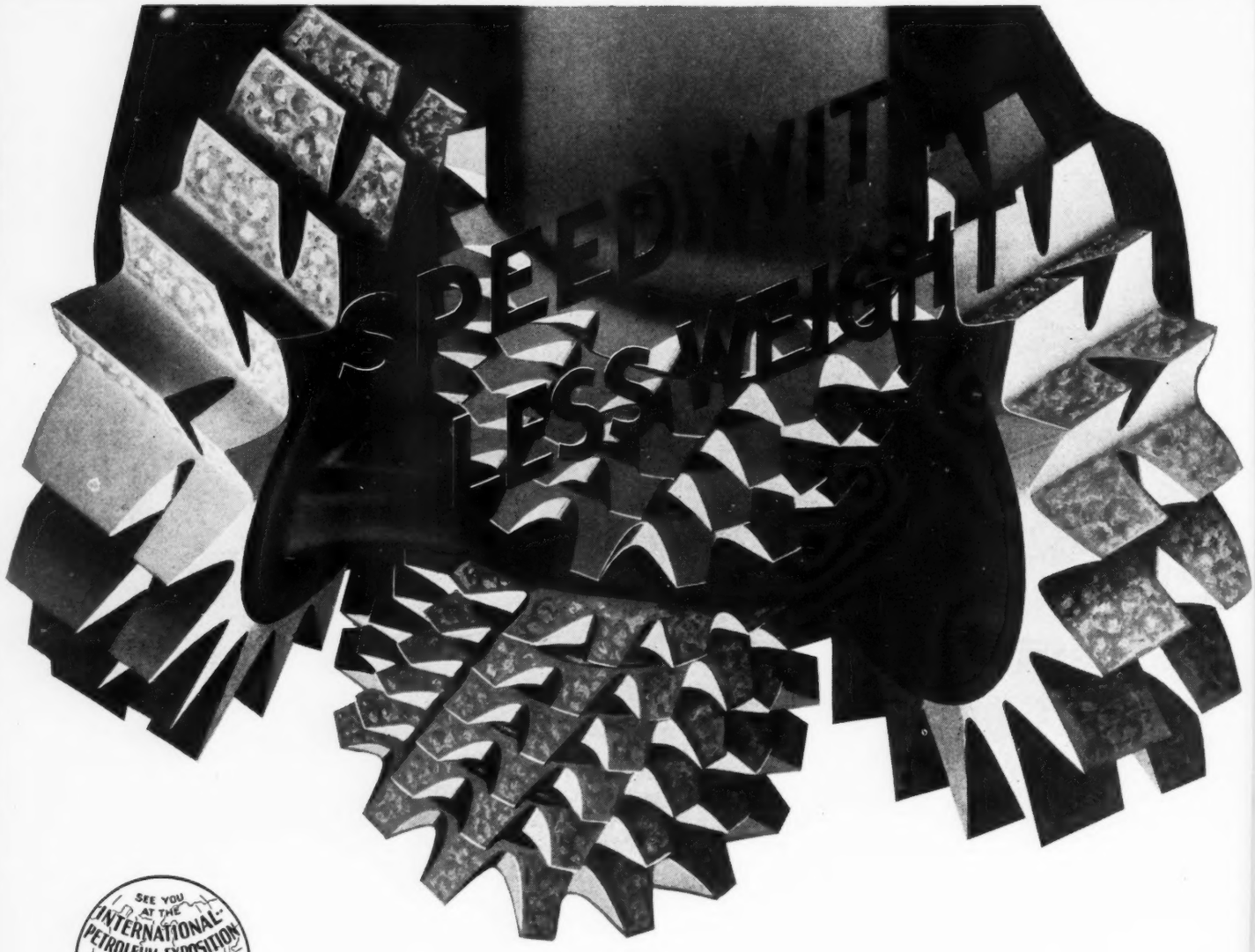
The illustrations show the machine in operation and the class of work accomplished. In the close-up photograph may be seen a portion of the pipe and the collar cleaned by a single pass of the rapidly revolving brush over the metal surface. The flexibility of the wire strands comprising the brush permits a thorough cleaning of the collar recess. This operation is a decided improvement compared to the older hand methods of scraping, filing, digging out rust and dirt accumulations in the collar recesses, and wire-brushing. It has been the practice in some cases where facilities have been available to burn out the sediment in the collar recesses with welding torches to facilitate hand-cleaning. The method herein described dispenses with the necessity for hand-cleaning.

Rotating brushes are not a novelty in pipe line work; but previously the application of high-speed brushes in the cleaning of pipe in the field has been largely through the use of compressed air as a source of power, necessitating heavy equipment and the means for its transportation. This new method requires only light equipment.

*Consulting Pipe Line Technologist, Los Angeles, Calif.



REED ROCK BITS



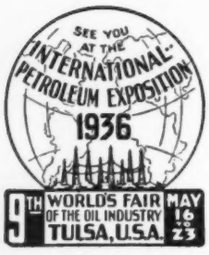


Fig. 2. Three wells being pumped from one location. These wells are on 2-ft. centers and form an equilateral triangle at the surface. Each well has its individual pumping unit and gas engine.

Tideland Development and Directional Drilling

Methods used to reduce pier construction costs and improve well-spacing on sand

By
WALLACE A. SAWDON

DEVELOPMENT of a tidewater lease or permit is an expensive operation. When vertically drilled wells must be relied upon for the purpose, the cost of pier construction is too great for the drilling of a sufficient number of wells for the efficient drainage of a large tract. Economies in tidewater operations are made possible by controlled directional drilling and what is probably more important, an entire lease can be developed without prohibitive preparatory expenditures.

Land on tidewater permits were first developed by building a pier to the first well location and then extending the pier for subsequent operations. This was costly and unless the wells were of sufficient size their drilling was not justfied; moreover, development naturally tended toward close locations from the shore out and wide distances between wells parallel to the shore when a permit extended for any considerable distance along the ocean. Although many tidewater tracts may be narrow with their greatest dimension extending oceanward from the shore, it is doubtful whether the productive area can be developed for most effective drainage by vertically drilled wells. The cost of pier construction naturally precludes surface locations comparable to those for similar areas on land.

Directional drilling has thus been used to great advantage for tidewater wells in both the Rincon and Elwood fields of California. Its more extensive application has been at Elwood where a distinct technique has been developed. Two methods have been used in utilizing the advantages of directional drilling in this field; one in which is employed a single derrick location for the drilling of two or three wells, and the other in which are employed adjoining derrick locations with each interior leg foundation pier serving for two derricks. A combination of the two methods that provides a unit for a drilling of seven wells is shown in Fig. 1.

A complete and detailed description of the drilling of three wells from one location by the Barnsdall Oil Company has been published in *The Petroleum Engineer*.[1] Each of these three wells is an individual operation and is equipped with its own pumping unit as shown in Fig. 2. Any one well can be shut down without interrupting the production of either of the other wells. When cleaning-out or

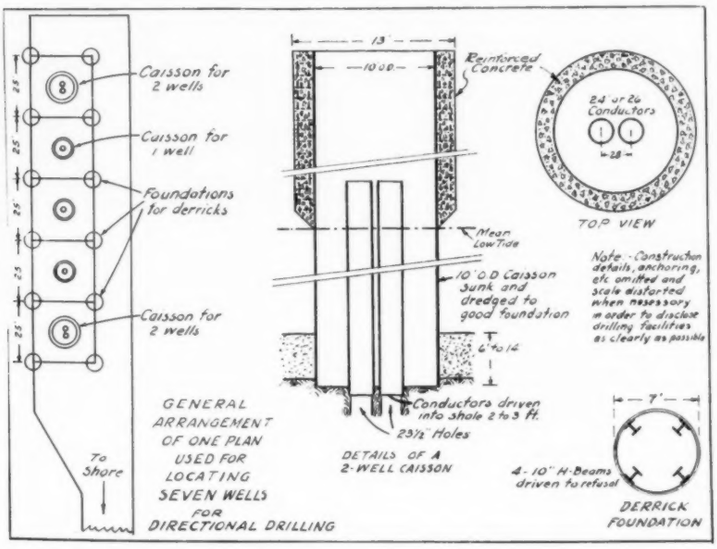

Caisson for 2 wells
Caisson for 1 well
Foundations for derricks
Caisson for 2 wells
To Shore
GENERAL ARRANGEMENT OF ONE PLAN USED FOR LOCATING SEVEN WELLS FOR DIRECTIONAL DRILLING
13
10'0"
Reinforced Concrete
Mean Low Tide
10'O.D Caisson Sunk and dredged to good foundation
6' to 14'
Conductors driven into shale 2 to 3 Ft.
23½" Holes
DETAILS OF A 2-WELL CAISSON
8 or 12 Conductors
28
TOP VIEW
Note - Construction details, anchoring, etc omitted and scale distorted when necessary in order to disclose drilling facilities as clearly as possible
7'
4-10" H-Beams driven to refusal
DERRICK FOUNDATION

Fig. 1. On left, plan for drilling a group of seven tideland wells by directional drilling; at right, details of derrick foundation and a two-well caisson.

[1] "Directional Drilling—A Means of Reaching Legitimate Bottom-Hole Locations Where Adverse Conditions Prevail," by Wallace A. Sawdon, *The Petroleum Engineer*, April, 1935.

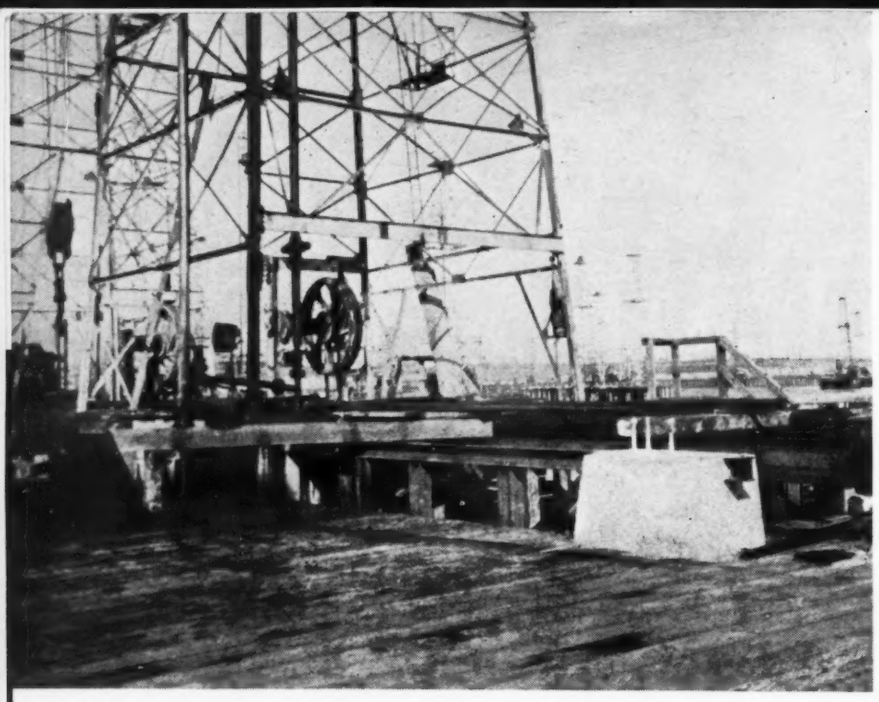


Fig. 3. Here are shown the steel floor beams and a leg foundation for a 2-well location at the end of a 7-well unit. When ready to drill these two wells, the derrick shown will be skidded over for the first well and later moved another 18 in. for the second well. Three anchor bolts (seen in the foundation at right) provide for this procedure.

other work has to be done on a well, however, there is interference with the production of the other two.

During the period that the wells are on gas-lift (as a great many in the Elwood field are at the present time) multiple wells at one location do not offer this inconvenience during work on one of the wells; but there is a delay in completion of the second well and a further delay for the third well when three wells are drilled from a single location. The expense of putting in the additional leg foundation piers for adjoining locations rapidly may be offset by delayed production or by subsequent shut down time and most of the operators seem to favor the drilling of only one well at each derrick location.

Yet there are certain advantages in drilling two wells from one derrick location and the procedure followed by the Pacific Western Oil Company in combining single and double well locations probably provides a minimum cost of pier construction for developing the company's tideland property at Elwood. It is of considerable extent but the 7-well unit, as shown in Fig. 1, is aimed to provide effective drainage of the more oceanward half of the area.

Caissons must, of course, be used for the drilling of wells whether the location is for one or more holes. For drilling a 2-well location, a steel caisson 10 ft. in diameter is sunk and dredged to a firm foundation and is surrounded above water by a reinforced concrete wall 18 in. thick. The distance below the ocean floor to which the 10-ft. caisson is carried will vary from 6 to 14 ft., depending upon the thickness of the sand bed overlying the shale.

A conductor for each well is driven from two to three ft. into the shale. The present practice is to keep both conductors vertical and in the 2-well location shown they consist of either 24-in. or 26-in. pipe and are spaced only 28 in. center to center.

The concentration of operations in the 7-well unit is evident in Fig. 1. The derrick leg foundations are built 25 ft. on centers and allow for the use of derricks with a 24-ft. base. The pier for each leg is constructed with four 10-in. "H" beams, which are driven to refusal and have been found

Fig. 4. This well tapped the productive zone within 15 ft. of the center of the area of 100 ft. diameter established as its desired location on the sand. Deflection was with a knuckle joint; only three settings of the deflecting tool were required.

Setting No. 1—Tool was faced 130 deg. around to the left and any roll-off, which would be to the right, up to about 30 deg. would not affect the new bearing materially but would show up as an increase in drift angle. Due to some peculiarity of the formation, the knuckle joint drilled out at a 7-deg. angle instead of the usual five deg. and gave the result as shown. This eliminated the necessity of a second run at this point.

Setting No. 2—The knuckle joint was set as shown so there would be an increase in inclination even were there no roll-off. With the roll-off obtained, the tool could have been faced a little more to the left but it was better to set it as indicated.

Setting No. 3—The tool was here set so that no roll-off would place the hole on one side of the center point of the objective and with maximum roll-off on the opposite side.

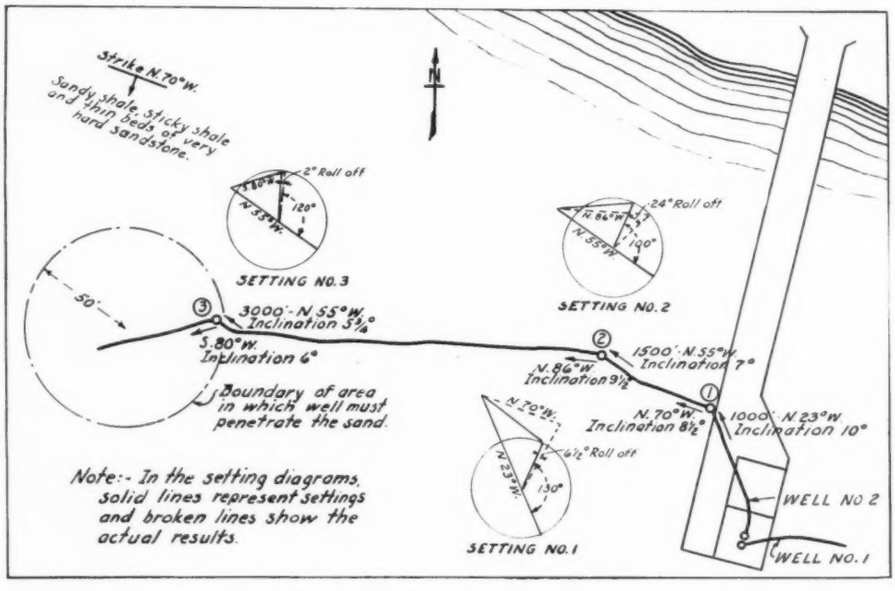


Fig. 6. Known as the "football reamer," this tool was developed for directional drilling and has been used successfully at Elwood.

to penetrate the shale from 10 to 16 feet. As shown in Fig. 3, three anchor bolts are provided in the foundation supporting each derrick leg. These permit a movement of 18 in. of the derrick in the 2-well location.

In drilling the wells, a 23½-in. hole is carried vertically to a depth of 400 or 500 ft. where a 16-in. or 18-in. surface string is cemented. Although these holes are only 28 in. c. to c. at the surface, no difficulty has been encountered in preventing their interception, for they are drilled with care and are surveyed at frequent intervals. The wells are then completed with a 15-in. hole to a depth of from 3400 to 3600 ft., depending on the vertical distance to the sand and the amount of horizontal drift necessary to reach their predetermined location. Either 10¾-in. or 11¾-in. casing is run and cemented on top of the sand.

All the directed wells to date in the Elwood field have been completed in the Vaqueros sand, which lies more than 3000 ft. below sea level. The measured depth of the deviated wells ranges from 3400 to 3600 ft., the variations being caused more by the horizontal drift required than by the structural conditions encountered. Deflections have been obtained both by whipstocks and knuckle joints, the majority now being made with knuckle joints.

The accuracy with which the holes are put on the sand with reference to a predetermined objective now is such that the horizontal distance of the completed well from the desired location is never more than 20 feet. Most of the wells hit much closer than this and some come within two ft. of the objective. A circular area with a diameter of 100 ft. is usually established as a requirement for penetration on the sand but with present directional drilling methods not that much leeway is required.

The average well put down by directional drilling in this field should require from four to five deflections. Some are drilled with only two or three, while as many as 25 or 30 have been required in others. It has been well established that the man in charge is a most important factor in obtaining success under normal conditions. Most of the companies doing directional drilling on tidewater leases place an engineer or other competent man in charge of the work and while he may not spend all his time on a particular well, he must be available for supervision whenever it is necessary.

Some of the companies supplying survey instruments and deflecting tools also provide supervision for controlling direction and such companies usually set the deflecting tools in the wells even when the actual drilling is done by the operator. They also handle all orientation of the deflecting tools in the hole, and advise whether to run a stiff or limber set-up and recommend the best table speed and weight to use.

Constant surveys for direction and inclination are necessary during the entire time of drilling. Single-shot instruments are used for this purpose and are run either by the operator or the survey company. The latter is generally kept advised of the operation and recommends when a deflecting tool should be run.

With the surface string set at from 400 to 500 ft., it is the usual practice to keep the hole approximately vertical for about 100 ft. after going out of the casing. The first deflection is then made and at this depth of from 500 to 600 ft. the well is generally off from one to two degrees, which is an advantage in setting the deflecting tool since it aids in getting direction.

Fig. 5. Knuckle joint (Lewis type) deflects hole in manner shown. It is oriented and deflects hole in a predetermined direction and at a different inclination from hole already drilled

The procedure followed in one well is shown in Fig. 4. This well started off without the use of deflecting tools after going out of the surface string and it was not necessary to use the knuckle joint until a depth of 1000 ft. had been reached. The knuckle joint was oriented into the well and began deflecting the hole in a predetermined horizontal direction as well as at a different inclination from the hole already made. Its general action is shown in Fig. 5. The "roll-off" shown in the settings in Fig. 4 are provided for when placing the tool in position in the well. An experienced operator can allow for this with considerable accuracy and begin the hole on its proper course with little difficulty.

While drilling after deflection, considerable attention must be paid both to the weight carried on the bit and the speed of rotation. Tachometers as well as weight indicators are in general use and most of the companies are doing directional drilling. The engineer in charge usually specifies the weight and table speed and soon can tell if these are being maintained when he takes the next survey reading.

The weight and table speed influence both horizontal and vertical directions of the well and must be varied to meet the conditions en-

Fig. 8. A 4-well unit with one boiler installation made for drilling all the wells. Other units may be added if desired and the same set-up used.

countered and make changes in the course the well takes. From settings, No. 2 in Fig. 4, the well continued along a desired course until it reached a depth of nearly 3000 ft., after which it went off a little and had to be deflected again at setting No. 3.

The extensive work of the Pacific Western Oil Company in directional drilling at Elwood resulted in considerable research in actual drilling during direction control as well as in developing economical surface plants. One result has been the design and invention of a "football" reamer by R. V. Plyler, a driller for the company. This reamer was immediately put into service by A. C. Bush, superintendent at Elwood, and has been the means of facilitating drilling.

The reamer, shown in Fig. 6, carries four demountable blades that are inserted in grooves and held in place by double-eccentric bolts. The blades are set with diamond substitutes and covered with tungsten carbide tube stock. They are the only protrusions and when the tool starts to ball-up it is merely dropped vertically to remove the ball.

In drilling the 15-in. hole from the surface string down, a 15-in. reamer is used with a 12½-in. bit, the reamer serving as a hole-enlarger and cutting out to 15 inches. This allows more rapid drilling and since using the hook-up, it has been found the deflected holes lose less than one degree in either inclination or direction. Most of the drilling is done with rock bits and the remainder with fish-tails, the reamer being used with both.

In deflecting the hole, the company uses a Lewis knuckle joint, shown in Fig. 5, which finishes up the inclined pilot hole with a diameter of 7⅝ inches. This is then reamed to 12½ inches. The 15-in. "football" reamer above a 12½-in. bit is then run and provides a flexible hook-up by being made up directly on top of the bit and with drill pipe made up on the reamer without a drill collar.

Although most of the tide-water properties are more or less regular in shape, any irregular areas that may be alloted can be readily developed by directional drilling methods. Assuming one as shown in Fig. 7, it may be desired to limit the number of wells in a unit and make more than one grouping as shown.

The amount of pier construction is naturally a factor to consider in all cases. With a long oceanward distance, however, a shorter horizontal drift may be desired for as many wells as possible with the longest drift being confined to the outward locations. One company has made adjoining derrick locations on a line parallel with the shore for the development of its permit. This is shown in Fig. 8 with a battery of boilers for the drilling of all the wells placed just off the pier connecting the locations with the land.

Directional drilling has been the means of penetrating the productive zone at a greater distance from shore than could be done with reasonable cost by vertical wells. Better well-spacing on the sand for greater yield has been made possible. In addition, considerable expense has been eliminated in drilling wells that otherwise would have been drilled vertically. The wells are made to penetrate the sand in such manner that they are more effective in draining the area within the permit. Consistent surveys during the entire operation provide assurance that the penetration of the well in the sand is kept within the boundaries of the lease or permit.

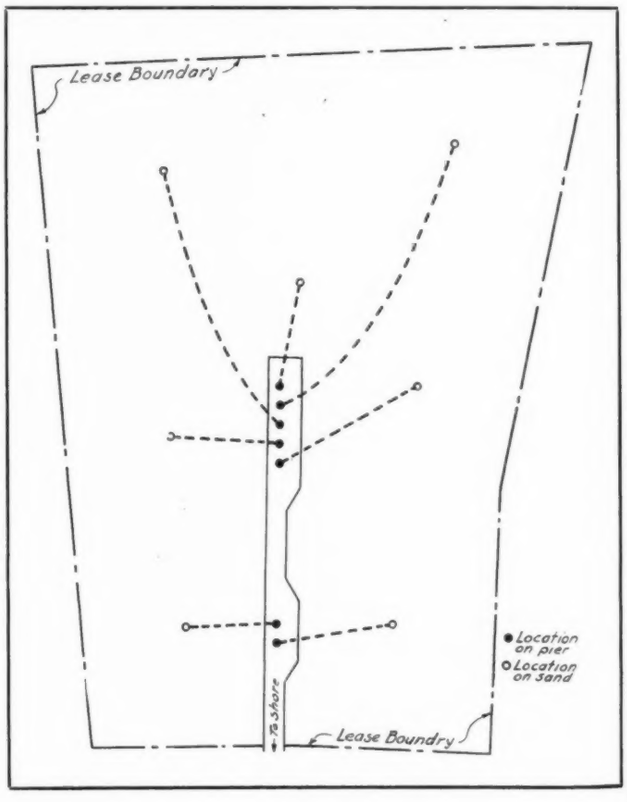


Fig. 7. Hypothetical tidewater lease or permit showing how directional drilling can be used to advantage. The two lower wells might also be included in the 5-well unit with economy if other conditions made it advisable

New Aids for Drilling Heaving Shale Being Tried

By K. C. SCLATER

Method in use at deep wildcat well in an effort to prevent "heaving" while drilling through great thickness of shale places reliance on the efficacy of sodium silicate mud and the maintenance of continuous circulation.

LAST month some of the chemical and mechanical difficulties of drilling shale that show an inordinate tendency to heave were recounted and a brief description of the methods used by the Continental Oil Company to overcome them. Within the past few weeks the Pure Oil Company, in its Paige No. 1, a wildcat well in Wharton County, South Texas, began drilling through shale of the so-called heaving type at a depth of 7676 feet.

The methods used by this company, although they may be considered a modification of those used by the Continental Oil Company, nevertheless also mark a distinct departure from orthodox practice.

Great interest attaches to the methods used in both these wells, for they may be the forerunner of a new and improved technique for the successful drilling of great thicknesses of shale that has a tendency to heave.

Like the Continental Oil Company, the Pure Oil Company is using a sodium silicate drilling mud, but the method of handling the drill pipe is different. Officials of the Continental Oil Company apparently were convinced that essential to the successful drilling of heaving shale: (1) Pulling of the drill pipe should be eliminated; (2) Circulation should be maintained continuously; and (3) The drilling bit should be kept on bottom and rotation maintained continuously except when changing bits and adding drill stem. By following a program that accomplished these essentials, approximately 2000 ft. of heaving shale was drilled successfully; but it precluded the taking of cores and running Schlumberger instruments for making a survey of the strata penetrated.

In an attempt to overcome these drawbacks, which are considered serious, especially in deep wildcat wells, the Pure Oil Company is adopting a different course, and in doing so, has a full appreciation of the risks involved, evidence of which is the elaborate preparations and precautions taken.

Drill pipe, instead of casing, is being used with a Barrett-Robishaw three-way bit on bottom so that cores can be taken by a wire-line coring bit without having to pull the drill pipe. It is intended to carry open hole through the shale, after which a Schlumberger survey may, if desired, be made before running the casing. Circulation is maintained continuously by means of full-hole continuous circulation joints[1] in the drill stem. This procedure calls for a method of handling the drill stem different from that used on the Continental Oil Company's well. In using it, great dependence is placed upon the efficacy of sodium silicate drilling mud and the maintenance of continuous circulation, two factors whose degree of protection in preventing "heaving" of the shale still remain to be determined.

A string of 13⅜-in. casing has been set and cemented in the well at a depth of 1420 ft., and a string of 9⅝-in. casing at 7676 ft. on top of the "heaving" shale.

Before starting to drill below the 9⅝-in. casing, elaborate preparations were made for handling the special sodium silicate mud and for maintaining continuous circulation.

Three vibrating screens, two of which are in use, the third being held as a standby, are installed in the mud system. Between the screens and mud pit a trough of ample dimensions has been constructed for the returns and is provided with a cover to prevent dilution of the mud by rain and also to cut down evaporation. Mud-making materials are fed into the mud system through a hopper and mixing pump.

Instead of drill casing, 4½-in. 18.15-lb. drill pipe is being used with Doheny-Stone internal flush joints, which, with the three-way Barrett-Robishaw bit on bottom, permit cores to be taken with a wire-line coring bit. A full-hole continuous circulation joint is screwed in top of each joint of drill pipe before it is added to the drill stem in the hole.

When a joint of drill pipe is added the drill stem is pulled up until the top circulation joint, which is just below the kelly and in top of top joint of drill stem, is above the rotary table. After setting the drill pipe in the rotary slips the plug in the continuous circulation joint is then removed and a 2-in. mud hose connection made as shown in Fig. 2 of last month's article[1]. Circulation is then begun through the 2-in.

[1] "Drilling Heaving Shale," by K. C. Sclater, *The Petroleum Engineer*, March, 1936.

connection in the continuous circulation joint and shut off through the 4-in. mud connection on swivel. The kelly is then unscrewed and another joint of drill pipe, with a continuous circulation joint on top, added, after which the kelly is reconnected to the drill stem and drilling resumed.

Only one continuous circulation joint is left in each stand (3 joints) of drill pipe as drilling progresses through the expected thickness of shale. This necessitates pulling of the drill stem at intervals to recover the intervening, continuous circulation joints added when adding drill stem.

Even while recovering these circulation joints, however, circulation is not stopped. When it is desired to recover the extra continuous circulation joints between stands of drill stem, the kelly is unscrewed and placed in the rathole; circulation is maintained while doing so through the 2-in. connection on the top circulation joint below the kelly in the same manner as already described when adding drill pipe.

A special 2-in swivel connection for the mud hose is then screwed into the top of the continuous circulation joint on top of the drill pipe in the hole. When this special 2-in. swivel connection for the mud hose is made, circulation is then begun through it and circulation through the continuous circulation joint stopped. The drill pipe is then pulled up until the next circulation joint to be left in the drill stem is above the rotary table. The plug is unscrewed from the continuous circulation joint and the 2-in. mud hose connection made, after which circulation is begun through the continuous circulation joint and circulation through the special 2-in. swivel connection stopped. The stand of drill pipe is then unscrewed, the continuous circulation joints between removed and the stand of drill pipe made up again to the drill stem in the hole. This process of removing the intervening continuous circulation joints is repeated as often as necessary so that only one continuous circulation joint is left in each stand of drill pipe in the hole.

It will be observed that although rotation is stopped for a short time, circulation is never stopped, even when pulling up to remove the extra continuous circulation joints between stands. The fact that circulation is maintained when pulling up probably reduces the severity of the swabbing action in the hole.

Heavy sodium silicate mud is being carried weighing on the average 14.4 lb. per gallon and consisting of approximately the following proportions: two parts of sodium silicate to one part of brine (a saturated solution of common salt), ten percent by weight of bentonite, and 1½ lb. of Baroid per gallon of mud. The proportions desired are maintained closely even when new mud is added. Approximately 900 bbl. of mud fluid is carried in the well's mud circulation system.

Up to the time of writing the drill pipe had been pulled from the hole twice, from a depth of 8070 ft. and again at 8809, when 1133 ft. of shale had been penetrated. At 8070 ft. the bit was off bottom some 36 hours; but no trouble was experienced in getting back on bottom. During the pulling of the drill pipe gas-cutting of the mud occurred causing the weight to drop suddenly to 10.1 lb. per gallon.

Laboratory facilities are provided at the well for testing the mud. Hourly readings are taken and these are carefully scrutinized and recorded. A close check is kept of the proportions of the ingredients in the mud and the mud conditioned as found necessary. These proportions are determined chiefly by titration. The physical properties of the mud are under careful observation at all time; any changes are immediately detected and steps taken to make what remedial measures are necessary. The accompanying table shows the record of daily mud data taken.

In addition to the daily mud data shown, a record is kept of mud pump speed in r.p.m., the weight on the bit, the

DAILY MUD DATA	DATE						
1. Bbl. silicate OH							
2. Bbl. saturated brine OH							
3 Bbl. silicate and brine (mixed 2 to 1 proportion by vol)							
4. Bbl reserve mud in 500bbl tank							
5. Bbl. mud, circ system							
6. Percent bentonite, circ system							
7. Brine concentration							
8. Silicate concentration							
9. Viscosity in cent. on Stormer							
10. Viscosity, F.F.							
11. Viscosity, P.P.							
12. Gel strength in grams { 0 min. / 10 min.							
13. Percent air in mud { out of well / into well / at suction							
14. Weight of mud { into well / out of well							
15 Loss or increase of Vol. of mud in circ system							
16 Temperature { out of well / into well							
17 Percent of sand							
18. Percent of solids							
19 Sacks of clay							

mud pump pressure, the number of hours hoisting, the number of hours reaming, the number of hours coring, and the number of hours down-time, including a report of the mechanical trouble causing the down-time. While drilling at approximately 8800 ft. or about 1000 ft. in the shale, the average mud pump pressure was 1250 lb. per sq. in., the speed of rotation 50 r.p.m., and the average recorded torque on the drill stem, 27½ points.

Every precaution has been taken against the possibility of a shut-down due to failure of any part of the equipment, all vital parts of which are duplicated. Drawworks are duplicated and steam is kept in the engines of the standby drawworks so they can be started up without a moment's delay. There are four 150-hp. boilers of 350-lb. working pressure. One of these is a spare and all except the spare is thoroughly lagged as are all steam lines to cut down condensation. A feed-water heater using exhaust steam from the pumps and engines maintains the feed-water temperature to boilers at 180-195 degrees. The boilers are equipped to burn either gas or oil fuel.

Drilling at present is progressing at a speed of 150 ft. per day.

Although at this writing the well is 8985 ft. deep, or some 1309 ft. in heaving shale, without encountering serious trouble it would be premature at this time to say that the method used in this well for drilling heaving shale is successful. The crucial test really will come when the drill pipe has to be pulled and the casing run. It can be stated, however, that remarkable success has attended the method thus far and that sodium silicate mud, combined with the maintenance of continuous circulation appears to be efficacious in preventing heaving.

It has been estimated that there is a loss of 36 to 50 lb. of mud per day in the hole and so far as can be ascertained no one ingredient suffers a greater loss than another. This fact, while it is of some concern from the standpoint of cost, may, by further investigation of its cause, throw some light on the action of the sodium silicate mud on the shale.

Alignment Trouble on Worn Shaft

Checking main shaft under full load disclosed the difficulty

By ELTON STERRETT

WITH more than 20,000 hours of service and approximately four years after being installed, the main bearings on a set of geared duplex plunger pumps were found to have worn to the point where the shaft had cut through the bottom section of the conventional quarter-box bearing enough to be rubbing against the oil retainer housing ring.

As opportunity offered, the various gear covers were lifted, the main gear and its shaft together with the integral cranks, hoisted clear, and all bearings minutely examined. Where the babbitt showed no sign of distress, was clear of cracks and flaws, and where the wearing surfaces of both bearing and shaft checked in with satisfactory arcs of contact under the usual test with Prussian blue, shims to replace the amount worn from the bottom shoe ("B" of Fig. 1) were put below it, the gear and its shaft replaced, and "Dutchmen" fastened to the back sides of shoes "F" to restore the original distance between main and pinion shafts, and the units again put on the line.

Apparently differing in no way from the pumps on either side of it, Unit No. 3 developed a baffling habit of heating up, on one side only, after undergoing the same overhaul as had been given its neighbors.

Always starting, when put on the line, with the satisfactory performance expected of it, this one side of the pump would seemingly fail to get sufficient lubrication and would heat up so rapidly that it was necessary to back off on the adjusting shoes holding side bearing "A" in place to prevent scoring. Then, after cooling down, perhaps the pump again would run quietly, but was just as likely to operate with a distinct thump for each reversal of stress in the rod.

Adjusting the bearing when the unit was shut down, no matter in what position the crank on that side was placed, failed to clear up the trouble. If the same amount of clearance was given this side as was customarily accorded the others—by turning up the adjusting screws "D-D" until tight and then backing off one-eighth turn—the pounding noise on starting was entirely eliminated, but soon after building up its load the trouble would reappear and slack would have to be provided, with consequent pounding and irregular operation.

Although the work of overhauling the drive had been carefully supervised and checked, it was surmised the trouble must in some manner be connected with or traceable to it, as no difficulty beyond the displacement of the shaft had been noted previous to that time.

Again the shaft was pulled, the bottom sections of right and left main bearings carefully rechecked and found to have been set dead level, so the main shaft was again put in place and checked on these bottom sections alone with Prussian blue. Everything met specifications; the side sections then being put in place, and also checking out as satisfactory. Finally the cap holding the top was pulled down against its shims on the main frame so that the upper section "T" could float with the shaft, yet permitted no vertical motion.

Assured by this check that nothing *could* be wrong, the unit was again put on the line—with no improvement. Then, when it was recalled that the bottom bearing "B" originally installed had been found to be cracked and as it had been

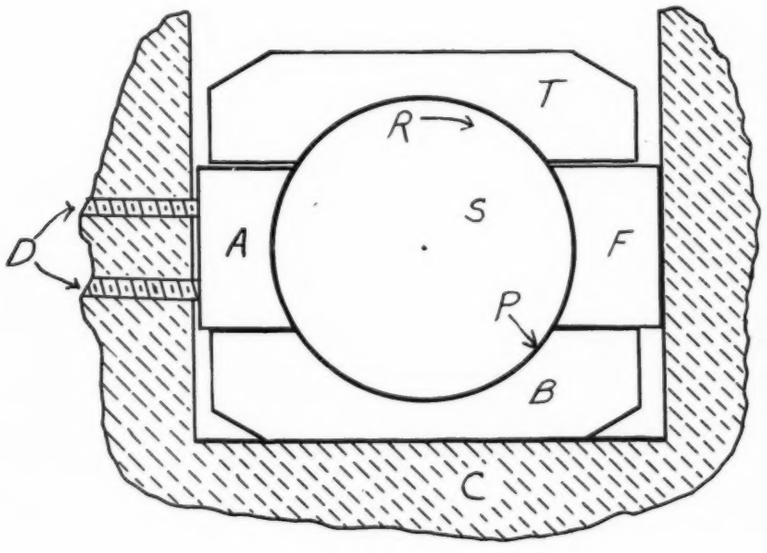


Fig. 1—Sketch of shaft bearing that gave trouble.

C—Pump frame casting
B—Bottom bearing
A—Adjustable bearing
F—Fixed quarter-bearing
T—Cap bearing
S—Pump shaft
R—Direction of rotation
D—Adjusting screws
P—Approximate point of maximum wear

replaced with a new section, the search for the trouble began to get warm.

A hint of the cause was found, and then ignored, when re-examination of the gear teeth was made by cleaning the contacting surfaces carefully on a pair of teeth in each arc midway between spokes and painting their surfaces with Prussian blue. As expected, the wear showed as a more or less irregular rectangular band roughly bisected longitudinally by the pitch line. This test was made with the pump by-pass open, and therefore under none but friction load. With the gear teeth again freed of suspicion, the bearing was, must be, the cause.

Against this suspicion of the new bearing was the fact that the check-up had showed satisfactory area of bearing contact after having had the usual initial scraping to fit; and it was not until the troublesome bearing was sketched and a rough graphic determination of stresses made that the underlying cause was discovered. As shown in Fig. 1, the maximum pressure, being the sum of components derived from rotatory force, gravity or weight of gear, gear reaction, and plunger resistance, acts in some direction approaching that of the arrow at "P", causing the greatest bearing wear, instead of being directly under the center of the shaft "S", to occur at a point some 35 degrees counterclockwise to it—rotation being clockwise—so that the lower or trailing edge of the non-adjustable side bearing "F" sustained most of the wear on this portion of the set-up.

Arcs of contact between shaft and this portion of the bearing remained practically constant, but instead of the chord of this arc remaining perpendicular to and bisected by the center line of the bearing, it was now below and at a slight angle to it.

Adding shims below all the other bottom bearings as the unit overhauls were made, in no way changed the relations between worn sections "B" and "F", and consequently no trouble was experienced. But when a new bottom shoe was used, the shaft was raised relative to the line at which "F" met "B", and the bearing "F" had to rise or "float" upward to bring its arc of contact into adjustment with the shaft. Without rotatory force to urge it toward contact with "B", this peculiarity failed to show up during the adjustment, but once rotation began, the drag of shaft against bearing tended to force it downward toward a seat on "B," with consequent wedging along the upper edge of "F", scraping off most of the lubricant and quickly causing trouble.

Action of that component of gear pressure tending to force the gears apart as well as others resulted in wear that allowed the shafts to move apart from their original relation and made it necessary to check closely to obtain proper contact between pinion and large gear.

All the gear sets, when the interacting faces were cleaned of lubricating compound and then rotated through a normal cycle of contact, showed that the section of wear had moved outward from its proper position astride the pitch circles of both gear and pinion, so that, illustrating one side of a herringbone gear, the wear is found to have moved out across the tooth to show somewhat as the shading at "D" in Fig. 2. "C" in Fig. 2 shows where the maximum wear would be found if the gears were set with pitch circles intersecting. Any of these shaded conditions may be reproduced with Prussian blue, being shown as bright or radially streaked spots through the color.

Assuming wrongly that the bearing conditions would be alike under no load and when fully loaded was responsible for much of the time lost attempting to find the trouble in this pipe line station, as a test made to determine tooth contact with by-pass closed and men enough on the engine jack-bar to rotate the pinion against full working pressures on the plungers showed a condition similar to, though not as pronounced as, that shown at "B", Fig. 2. Here all the load is applied on the outer corner of one side of the tooth, leaving the remainder of the normally working surfaces untouched.

Angularity between the shafts, not present when the pinion and main shafts were trammeled for parallelism with no load, was readily found with the working faces loaded as when under service conditions. Such angularity, once determined, could be obtained only by the restraining sections of the bearings—sections "F" of Fig. 1—yielding in some way. Had this check been applied when the usual sources of trouble were checked and cleared, the fact of an axial shift would have been established and correction speedily made.

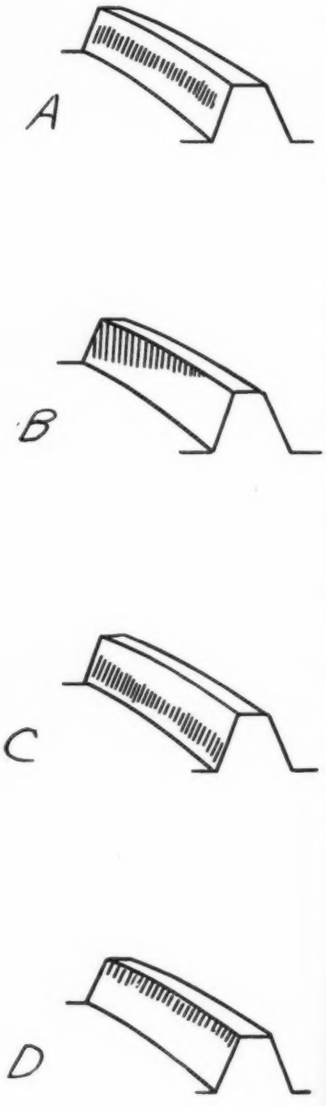


Fig. 2—Shaded portions show contact surfaces on gear teeth (see text)

A—Contact surface, normal gear setting
B—Contact, gear axes askew
C—Contact, pitch circles intersecting
D—Contact, pitch circles not tangent

Design of Sucker Rod Strings

PART 3

Formulas Have Been Developed for 1-in. Rods and for Tapered Strings Composed of Three Rod Sizes

By
EMORY N. KEMLER

THE recent introduction of 1-in. diameter sucker rods should, as far as strength is concerned, make it possible to reduce sucker rod failures on heavy wells and to use larger pump sizes on wells at present operating within the safe load limit. In this article are given not only formulas for 1-in. rods corresponding to those given previously, but also formulas for a tapered string composed of three rod sizes. They are based on the assumption that the maximum load occurs at or near the middle of the stroke; the acceleration factor can be applied if desired. The formulas are developed from the standpoint of strength only, such practical considerations as possible difficulty in fishing the 1-in. rods in small tubing, and the increased possibility of telescoping the smaller rods in a tapered string of three sizes must of course be considered.

(a) *1-in.-⅞-in. tapered string to replace a ⅞-in. string.* This case comes under the general heading of a uniform string to be replaced by a tapered string with larger sizes at the top and can be solved by use of Equation 12 (see January issue, p. 36). This reduces to:

$$l_1 = .092\ W \quad - - - - - - - - - - \quad (1)$$

It must be remembered that W is well load before size is changed and l_1 is the length of 1-in. rods.

The maximum stress reduces to:

$$S_{max.} = 1.33\ W \quad - - - - - - - - - \quad (2)$$

and the new well load will be

$$W_t = 1.05\ W \quad - - - - - - - - - - \quad (3)$$

Fig. 1 gives the maximum load that a uniform or tapered rod string having 1-in. rods can carry with a given stress. For instance, with a maximum allowable working stress of 30,000 lb. per sq. in. the well load giving this stress will be 23,600 lb. for 1-in. rods as compared with 18,000 lb. for a ⅞-in. rod under the same working stress.

(b) *1-in.-⅞-in. tapered string to replace ⅞-in.-¾-in. string.*

In this case let W represent, as before, the well load when the ⅞-in.-¾-in. rods are used; also let:

l_1 = length of 1-in. rods
l_2 = length of ⅞-in. rods in new string
l_3 = length of ⅞-in. rods in old string
l_4 = length of ¾-in. rods in old string.
W_1 = weight per ft. of 1-in. rods = 2.85 lb. per ft.
W_2 = weight per ft. of ⅞-in. rods
W_3 = weight of ¾-in. rods.

The new well load when the 1-in.-⅞-in. string is substituted will become:

$$W_t = W - W_2 l_3 - W_3 l_4 + w_1 l_1 + w_2 l_2 \quad - - - \quad (4)$$

The stress in the 1-in. rods will be given by

$$S_1 = \frac{W_t}{A_1} \quad - - - - - - - - - - - \quad (5)$$

The stress in the top of the ⅞-in. rods of the new string will be:

$$S_2 = \frac{W_t - W_1 l_1}{A_2} \quad - - - - - - - - - \quad (6)$$

If the stresses in the two sizes are to be made the same, we have on equating Equations 5 and 6 and solving for the length of larger rods:

$$l_1 = \frac{\{W + (W_2 - W_3)\ (l - l_3)\}\ (A_1 - A_2)}{W_1 A_2 + W_2\ (A_1 - A_2)} \quad (7)$$

This equation reduces for this special case to:

$$l_1 = .0864\ W + .0544\ (l - l_3) \quad - - - - \quad (8)$$

As an example consider a 4000-ft. well with a maximum well load of 20,000 lb. and 2000 ft. of ⅞-in. and 2000 ft. of ¾-in. rods. Equation 8 shows that about 1840 ft. of 1-in. rods should be used and, therefore, 2160 ft. of ⅞-in. rods are needed.

(c) *⅞-in.-¾-in. tapered string to replace a ¾-in.-⅝-in. tapered string.*

This case can be solved by substituting in Equation 7, and the length of ⅞-in. rods can be found from the equation:

$$l_1 = .125\ W + .062\ (l - l_3) \quad - - - - \quad (9)$$

(d) *1-in.-⅞-in.-¾-in. tapered string to replace a ⅞-in.-¾-in. string.*

This specific problem will be developed in general terms first so that it can be applied to any other similar case where other sizes are used.

Let l_1 = length of 1-in. rods to be used
l_2 = length of ⅞-in. rods to be used in the new string
l_3 = length of ¾-in. rods to be used in new string
l_4 = length of ⅞-in. rods in old string
$(l - l_4)$ = length of ¾-in. rods in old string.

We have, using the same argument as before, that the new well load will be given by:

$$W_t = W - W_2 l_4 - W_3 (l - l_4) + W_1 l_1 + W_2 l_2 + W_3 l_3$$
$$= W + l_1 (W_1 - W_3) + l_2\ (W_2 - W_3) + l_4\ (W_3 - W_2) \quad - - - - - - - - - - \quad (10)$$

The stress in the 1-in. rods will be:

$$S_1 = \frac{W + l_1 (W_1 - W_3) + l_2 (W_2 - W_3) + l_4 (W_3 - W_2)}{A_1} \quad (11)$$

The stress in the ⅞-in. rod will be given by $S_2 =$

$$\frac{W + l_1 (W_1 - W_2) + (W_2 - W_3) l_2 + l_4 (W_3 - W_2) - W_1 l_1}{A_2} \quad (12)$$

Likewise the stress in the ¾-in. rod will be: $S_3 =$

$$\frac{W + l_1 (W_1 - W_3) + (W_2 - W_3) l_2 + l_4 (W_3 - W_2) - W_1 l_1 - W_2 l_2}{A_3}$$

$$- - - - - - - - - - - - - - - \quad (13)$$

If the stress is to be the same in each size the problem becomes one of solving Equations 11, 12, and 13 simultaneously for l_1 and l_2. The solution of these equations gives:

$$l_1 = \frac{W_2\,(A_1 - A_2)\,\{W + l_4\,(W_3 - W_2)\,\}}{A_3(W_2 - W_3)(W_1 + W_2 - W_3) + A_1 W_2^2 - A_2 W_2 (W_2 - W_3) - W_3 (W_1 - W_3)} \quad - - - - - - - - - - - - \quad (14)$$

$$l_2 = \frac{(A_2 - A_3)\,(W_1 + W_2 - W_3)\,[W + l_4\,(W_3 - W_2)\,]}{A_3(W_2 - W_3)(W_1 + W_2 - W_3) + A_1 W_2^2 - A_2 W_2 (W_2 - W_3) - W_3 (W_1 - W_3)} \quad - - - - - - - - - - - - - - \quad (15)$$

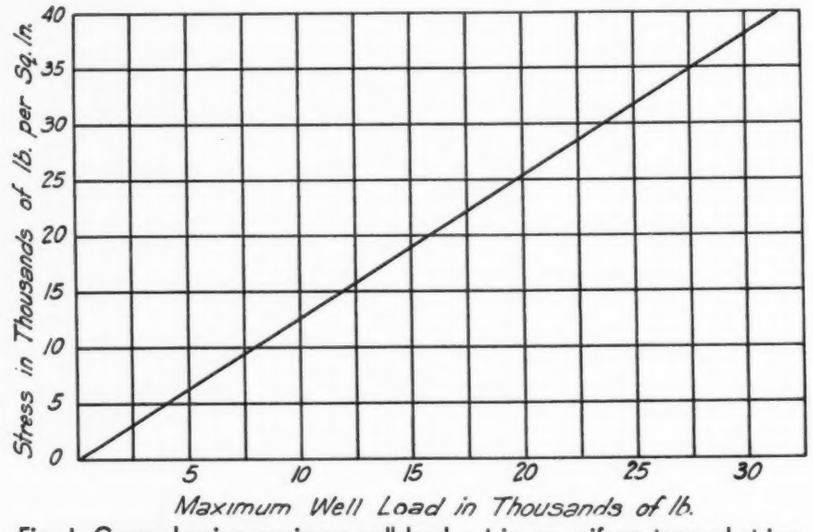


Fig. 1. Curve showing maximum well load a 1-in. or uniform tapered string of sucker rods can carry

On the substitution of the numerical values then equations reduce to the form:

$$l_1 = .078\,W - .0486\,l_4 \quad - - - - - - - \quad (16)$$

$$l_2 = .104\,W - .0645\,l_4 \quad - - - - - - - \quad (17)$$

Consider as an example the previous case of a 20,000-lb. well with 2000 ft. of ⅞-in. rods and 2000 ft. of ¾-in. rods. Equation 16 shows that 1460 ft. of 1-in. rods are needed and Equation 17 gives 1950 ft. of ⅞-in. rods are needed. The difference between these and 4000 ft. will be the number of feet of ¾-in. rods needed. This will be 490 ft. for this case. The increased danger of corkscrewing the ¾-in. rods will probably not justify the use of so few ¾-in. rods.

Working Stresses for Sucker Rods

The formulas that have been given by lengths of rods do not take into consideration the actual magnitude of the stress. Formulas have been included, however, for calculating the maximum stress, and the chart in this and the previous article permits the checking of the actual stress under which the rods are working.

The determination of the allowable stress that should be used for a given steel is a very difficult problem and one on which designers are likely to have very different opinions. The working stress will depend on the properties of the material and on the conditions under which the steel will be used. These latter conditions also determine which of the properties of the material are to be the controlling ones.

The conditions under which sucker rod failures most frequently occur are unfortunately those under which it is most difficult to determine the working stress. The failure of sucker rods where stress is a factor is almost always by fatigue. Unfortunately the fatigue limit of the steel depends on whether the medium in which it works is corrosive and the degree of corrosiveness of the fluid. Data on the fatigue limit have been determined for sucker rod steels under different conditions of corrosion[1, 2] and the results on ordinary steel show the corrosion fatigue limit to be about half the fatigue limit as determined in air and that the fatigue limit in a corrosive fluid containing hydrogen sulphide to be about one-fourth that of the fatigue limit as determined in air. Recent work has resulted in the development of steels that have a high corrosion and sulphide-corrosion fatigue limit and these steels have a higher ratio of ultimate to fatigue strength than that of ordinary steels. The fatigue limit as determined from tests with a rotating beam type specimen that gives a complete reversal of stress is lower than that without a complete reversal of stress. While the effect of range of stress on fatigue limit has not been completely determined the following formula[2] gives a safe evaluation:

$$S_{max.} = \frac{1.5S^{-1}}{1.0 - 0.5r} \quad \text{or}$$

$$\frac{S_{max.}}{S^{-1}} = \frac{3}{2 - r}$$

Where:

$S_{max.}$ = maximum unit stress during a cycle

S^{-1} = fatigue limit for complete reversal of stress

r = range ratio for the cycle (the algebraic ratio of minimum stress to maximum stress).

If the load is considered to vary from zero to a maximum, the fatigue limit is seen to be 150 percent higher than with complete reversal of stress.

In addition to the corrosiveness of the fluid and the range of stress, the question of stress concentration should be considered. This is particularly important where pitting occurs. The segregation of this factor from the effect of corrosion may not be possible as they occur simultaneously. The stress concentration factor will probably vary from one to two, depending on the shape of the pits and the sensitivity of the material to stress concentration. This latter factor being one on which much more information is needed.

The factor of safety to be applied depends on how many factors have been taken into account, the property of the material to which it is applied, and how the load conditions are determined. If for example the well is weighed and the load is known within one or two thousand pounds the factor of safety can be lower than if it is arbitrarily assumed. If a stress concentration factor is applied to the fatigue limit under the proper stress range and conditions of corrosion the factor of safety need be made only slightly greater than one. If, however, the factor of safety is to be applied to the ultimate strength without allowance for stress concentration or corrosion fatigue it may have values between three and ten, depending on the material and well conditions.

This discussion has disclosed the factors that must be considered in the selection of working stress. The careful analysis of field data and operating conditions and the checking of sucker rod loads will do much to show the working stress that should be used.

[EDITOR'S NOTE: Addition of this article to the other two on the design of sucker rod strings was made because of the recent introduction of 1-in. sucker rods for pumping deep wells.]

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[1] "Economic Selection of Sucker Rods," by Blaine B. Wescott and C. Norman Bowers—A.I.M.E. Petroleum Development and Technology, 1935.

[2] "Corrosion Fatigue and Sucker-Rod Failures," by Blaine B. Wescott and C. Norman Bowers—A.P.I. Production Bulletin 212, 1933.

A Bureau of Mines Study of a "Bottom Hole" Sample from the Crescent Pool, Oklahoma

with Regard to Liberation of Gas Expansion of the Oil-Gas Mixture, and Energy Relations Involved in flow[1]

By BEN E. LINDSLY[2]

Part 3

Flash Liberation and Pressure-Volume Relations of Bottom-Hole Oil

Knowledge of the volume occupied by a natural oil-gas mixture at different pressures and temperatures is essential to an analysis of the transformations of energy involved in flow.

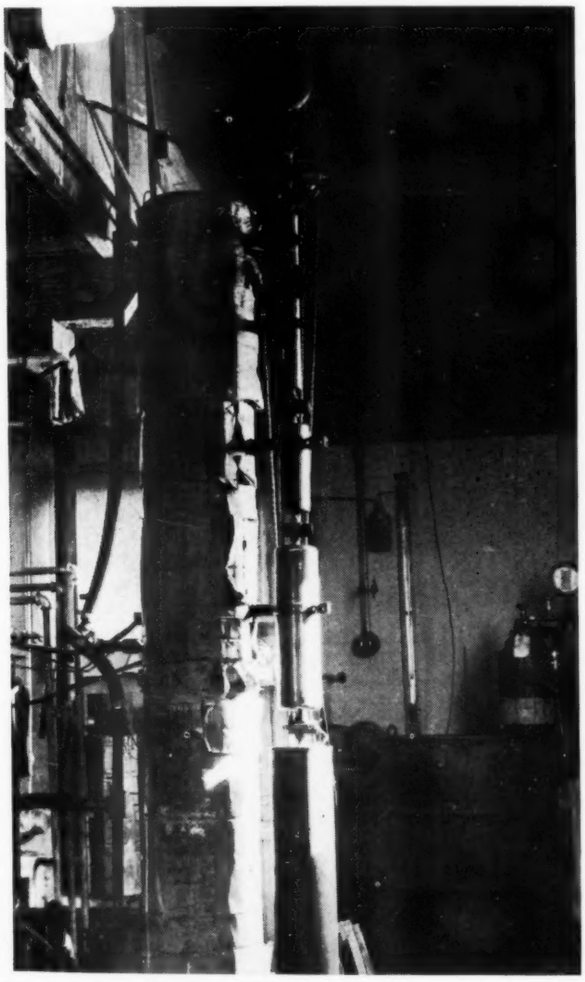


Fig. 11. Assembly of bomb, gage, and expansion chambers for determining pressure-volume relations by flash liberation; also water bath in which assembly is immersed during a test.

Since the gas liberated from the oil flowing in a well remains in contact with oil (though not necessarily the identical oil from which it was liberated), in the work discussed in this paper pressure-volume relations of the bottom-hole sample were determined by flash liberation. Using the pressure-volume data thus obtained, diagrams, calculations, and estimates relative to energy relations are presented.

Method Used in Determining PV Relations

In making PV tests a sample of oil, usually 100 cc., is withdrawn into a small laboratory bomb from the bottom-hole sampler without loss of pressure, as described previously in this report. The sample in this bomb then is stabilized at bottom-hole pressure and at bottom-hole or some other desired temperature. In the present instance tests were made at the bottom-hole temperature of 149° and 70° F. After the sample has been stabilized an evacuated pressure gage is connected to the top of the bomb and a series of evacuated expansion chambers, each larger than that above it, is connected to the bottom of the bomb (see fig. 11). The gage, expansion chambers, and fittings all are calibrated for volume before they are connected. With the assembly at the desired temperature the stopcock between the laboratory bomb and the pressure gage is opened, and the sample expands to fill the system comprising the bomb, gage, and fittings. Following this expansion and subsequent stabilization of temperature and pressure the stopcock at the bottom of the bomb is opened and the sample expands to fill the system composed of the laboratory bomb, upper expansion chamber, gage, and fittings. This process is continued, allowing the sample to expand into successively larger volumes by progressive opening of the stopcocks between the expansion chambers. After each expansion the temperature is stabilized at the value selected for the test, and the pressure is observed.

The assembly of laboratory bomb, gage, and expansion chambers for expanding a sample from bottom-hole pressure to atmospheric pressure, shown in fig. 11, is suspended by a rope which runs through an overhead pulley. It is held in place while the expansion chambers are being attached by clamps fastened to the insulated constant-temperature water bath shown at the left in the photograph. When a test is in progress the assembly is immersed in the water bath, except during short periods when it is raised for connecting an additional expansion chamber or opening a stopcock.

Results of PV Tests

Curve A, fig. 12, shows the volumes occupied by the bottom-hole sample at successively lower pressures when it was

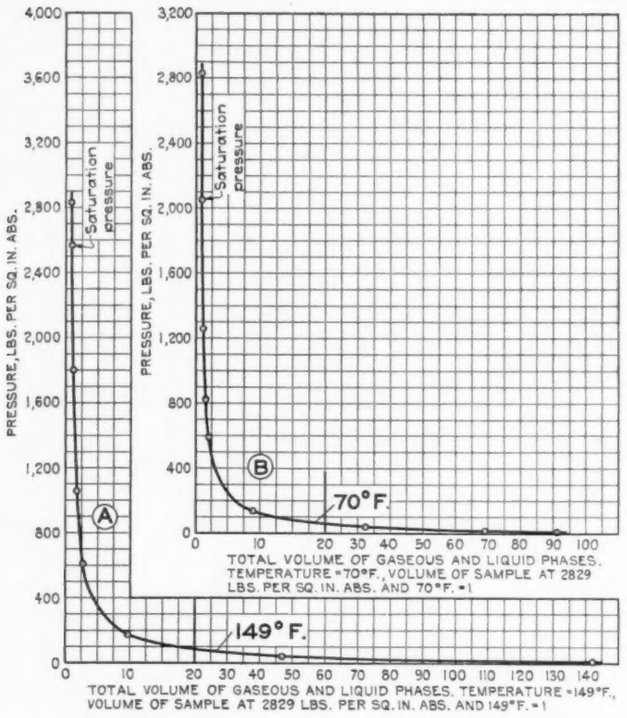

PRESSURE, LBS. PER SQ. IN. ABS.
Saturation pressure
A
149° F.
TOTAL VOLUME OF GASEOUS AND LIQUID PHASES. TEMPERATURE = 149°F., VOLUME OF SAMPLE AT 2829 LBS. PER SQ. IN. ABS. AND 149°F. = 1
PRESSURE, LBS. PER SQ. IN. ABS.
Saturation pressure
B
70° F.
TOTAL VOLUME OF GASEOUS AND LIQUID PHASES. TEMPERATURE = 70°F., VOLUME OF SAMPLE AT 2829 LBS. PER SQ. IN. ABS. AND 70°F. = 1

Fig. 12. Pressure-volume relations for Crescent Pool, Oklahoma, bottom-hole sample expanded with flash liberation.

expanded isothermally at 149° F., taking the volume occupied at 2829 lb./in.² abs. and 149° F. as unity. Curve B shows corresponding data from an isothermal expansion at 70° F., taking the volume occupied at 2829 lb./in.² abs. and 70° F. as unity. Lack of facilities in the field laboratory for accurate determination of the weight of a small volume of oil contained in a heavy bomb made it necessary to base determinations of the quantity of fluid in a bomb on volume at a given temperature and pressure rather than on weight.

Curves A and B, fig. 12, look much alike, but when the data are plotted on logarithmic paper (curves A_1 A_2 A_3 and B_1 B_2 B_3, fig. 13) the differences between the expansions at the two temperatures become apparent.

In plotting curve A_1 A_2 A_3, fig. 13, the volume of the liquid bottom-hole sample at the reservoir pressure of 2829 lb./in.² abs. and 149° F. is 1, by definition. As the pressure fell there was a slight liquid expansion before liberation of gas, giving the sample a volume of about 1.0025 at the saturation pressure of 2575 lb./in.² abs. (table 1 and fig. 7). At 1800 lb./in.² abs. the volume of the sample (liquid plus gas) was approximately 1 1/6. The data from the flash liberation do not indicate the exact path of expansion of the two-phase mixture above this pressure; but experience with other hydrocarbon mixtures, which has been drawn upon in plotting curves A_1 A_2 A_3 and B_1 B_2 B_3 throughout their lengths, indicates that the straight-line A_1 is a fair approximation of the pressure-volume relations above the pressure of 2000 lb./in.² abs.

Through the pressure range from 1700 lb./in.² abs. to about 850 lb./in.² abs. the pressure-volume relation can be represented approximately by straight line A_2, and from about 600 lb./in.² abs. to atmospheric pressure the relation seems to be satisfied by straight line A_3, whose slope is somewhat less (numerically) than that of A_2. The exact nature of the parts of the curve connecting straight lines A_1, A_2, and A_3 is not known, but tests of oil from the Oklahoma City field indicate that the relations in these regions may be represented best by curved lines, as shown in fig. 13.

In plotting curve B_1 B_2 B_3, fig. 13, the volume of the liquid sample at the reservoir pressure of 2829 lb./in.² abs. and 70° F. is taken as 1. As the pressure fell liquid expansion increased the volume of the sample to about 1.0096 at the saturation pressure of 2050 lb./in.² abs. (table 1 and fig. 7). Below the saturation pressure curve B_1 B_2 B_3 is similar to curve A_1 A_2 A_3 but lies somewhat lower, as is to be expected, because at any given pressure the volume of the 70° F. sample should be smaller than that of the 149° F. sample.

It is important to note that curves A_1 A_2 A_3 and B_1 B_2 B_3, fig. 13 (likewise curves A and B, fig. 12) are not based on the same quantities (masses) of sample. Estimating that the oil would shrink about 4.2 percent in volume with a reduction in temperature from 149° to 70° F. at the constant pressure of 2829 lb./in.² abs.[13] and defining a unit mass of the sample as the quantity occupying a volume of 1 cu. ft. at the pressure of 2829 lb./in.² abs. and 149° F., if curve A_1 A_2 A_3 represents the pressure-volume relations for one unit mass, curve B_1 B_2 B_3 represents the relations for $\frac{1}{0.958} = 1.0438$ unit mass.

Curve B'_1 B'_2 B'_3 (not shown in the figure) representing the pressure-volume relations of one unit mass (as above defined), expanding at 70° F. lies to the left of curve B_1 B_2 B_3 and parallels it. At each pressure the volume indicated by curve B'_1 B'_2 B'_3 is 95.8 percent of that indicated by curve B_1 B_2 B_3.

According to the pressure traverse by Sidwell and Collins,[14] 1 cu. ft. of the bottom-hole sample measured at 149° F. and 2829 lb./in.² abs. weighs 45.8 lb. Curves A_1 A_2 A_3 and B'_1 B'_2 B'_3 represent the pressure-volume relations for this mass of sample at 149° and 70° F., respectively, whereas curve B_1 B_2 B_3 represents the pressure-volume relations at 70° F. of $\frac{45.8}{0.958} = 47.8$ lb. of sample.

ENERGY RELATIONS

General Equations for Flow of Fluids[15]

Although the commonly used equations for flow of compressible fluids are based on assumptions that are not strictly applicable to the movement of an oil-gas mixture from its position in the sand to the surface, such equations and the methods of their development are helpful to an analysis of the experimental data reported in this paper. Therefore, they will be discussed briefly, using the following notation:

F = cross-section of channel.
w = velocity of fluid, ft./sec.
g = acceleration due to gravity, ft./sec./sec.
u = intrinsic energy of fluid (molecular kinetic plus molecular potential energies), ft-lb. (or B.t.u. × 778)/lb. of fluid.
p = pressure, lb/ft.² abs.
P = pressure, lb./in.² abs.
v = specific volume of fluid, cu. ft./lb.; that is, the volume in cu. ft. occupied by 1 lb. of the fluid.

[13] Abridged Volume Correction Table for Petroleum Oil, Supplement Issued October 27, 1931, to National Standard Petroleum Oil Tables, Circ. 154, Bureau of Standards, gives 0.0005 and 0.0006, respectively, as the coefficients of expansion at 60° F for oils of specific gravities at 60° F. of 0.8063 (44° A.P.I.) and 0.7467 (58° A.P.I.). Straight-line interpolation between these values gives a coefficient of expansion of 0.00056 and a specific gravity of 0.773 at 60° F. for the bottom-hole oil here considered having a specific gravity of 0.736 at 149° F. On this basis the volume of a given mass of the oil at 70° F. is

$$\frac{1 + (.00056 \times 10)}{1 + (.00056 \times 89)} \times 100 = 0.958 \text{ percent of the volume at 149° F.}$$

[14] See footnote 5, p. 35, of *The Petroleum Engineer*, February, 1936.

[15] A discussion of flow of fluids by R. A. Cattell, chief engineer, Petroleum and Natural-Gas Division, Bureau of Mines, contained in bureau correspondence, has been drawn upon freely in preparing the material presented under this subheading.

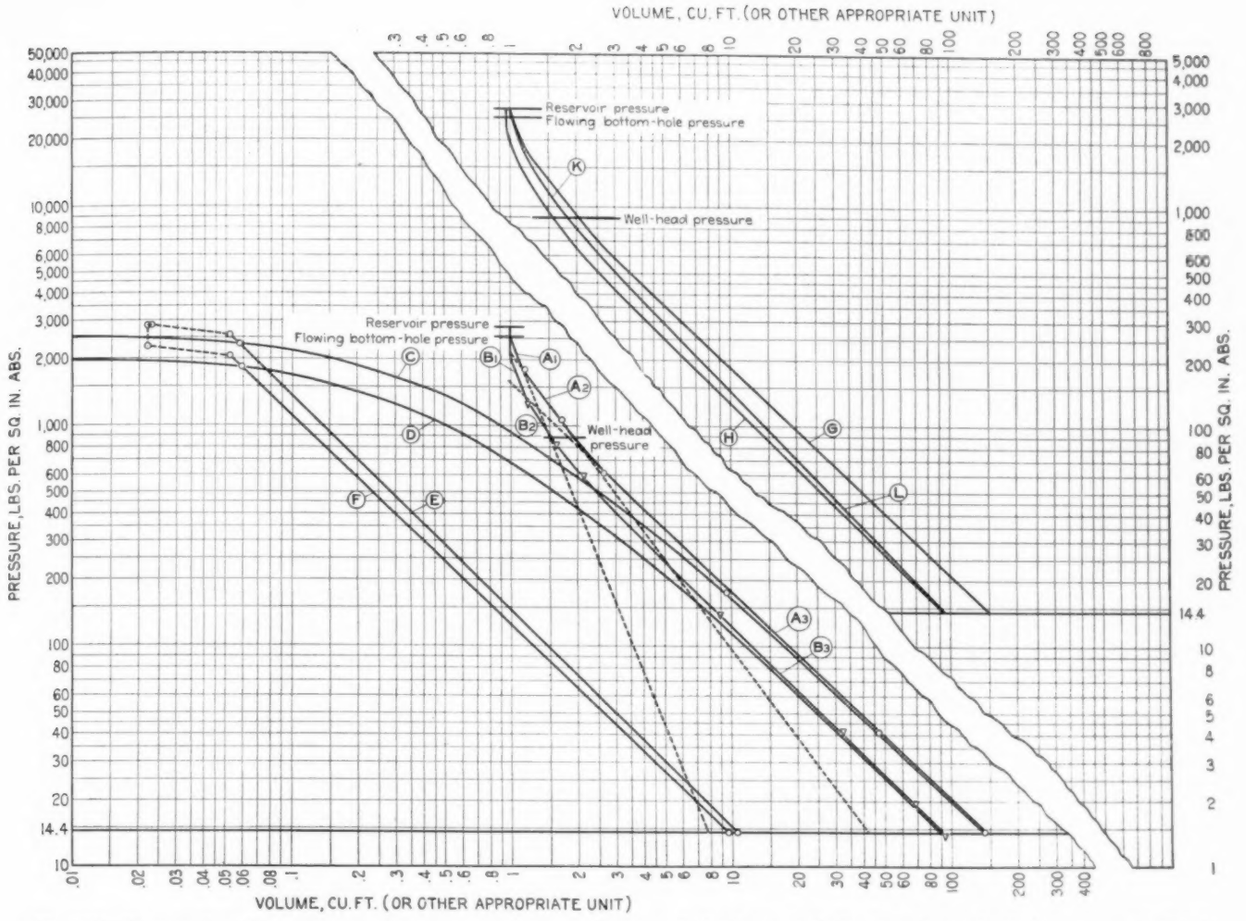


Fig. 13. Curves for the analysis of pressure-volume relations of the bottom-hole sample and of the reservoir fluid.

Pressure-volume relations for Crescent Pool, Oklahoma, *bottom-hole* sample and *reservoir fluid* expanded with flash liberation

$A_1A_2A_3$—Observed *PV* curve for a unit volume of *bottom-hole sample* measured at 2829 lb./in.² abs. and 149° F., expanding isothermally at 149° F.

$B_1B_2B_3$ —Observed *PV* curve for a unit volume of *bottom-hole sample* measured at 2829 lb./in.² abs. and 70° F., expanding isothermally at 70° F.

C —Estimated *PV* curve for the *gas phase* of the *bottom-hole sample* whose total volume (liquid plus gas) is represented by curve $A_1A_2A_3$.

D —Estimated *PV* curve for the *gas phase* of the *bottom-hole sample* whose total volume (liquid plus gas) is represented by curve $B_1B_2B_3$.

E —Estimated *PV* curve for the gas that would be liberated between 2829 and 2575 lb./in.² abs. in isothermal expansion at 149° F. of the quantity of *reservoir fluid* that would have a liquid phase at 2575 lb./in.² abs. equal in mass and composition to the bottom-hole sample represented by curve $A_1A_2A_3$.

F —Estimated *PV* curve for the gas that would be liberated between 2829 lb./in.² abs. (or the reservoir-fluid saturation pressure at 70° F. of 2273 lb./in.² abs.) and 2050 lb./in.² abs. in isothermal expansion at 70° F. of the quantity of *reservoir fluid* that would have a liquid phase at 2050 lb./in.² abs. equal in mass and composition to the bottom-hole sample represented by curve $B_1B_2B_3$.

Note: *E* and *F* represent the pressure-volume relations (as estimated by the method described in appendix A) at 149° and 70° F., respectively, of the quantities of gas that would have to be added to the *bottom-hole samples* represented by curves $A_1A_2A_3$ and $B_1B_2B_3$, respectively, to bring these samples to *reservoir-fluid* composition.

G —Estimated *PV* curve for unit volume of *reservoir fluid* measured at 2829 lb./in.² abs. and 149° F., expanding isothermally at 149° F.

H —Estimated *PV* curve for unit volume of *reservoir fluid* measured at 2829 lb./in.² abs. and 149° F. (equivalent to 0.962 unit volume measured at 2829 lb./in.² abs. and 70° F.), expanding isothermally at 70° F.

KL —Estimated *PV* curve for unit volume of *reservoir fluid* measured at 2829 lb./in.² abs. and 149° F., expanding with temperature falling gradually from 149° F. at 2829 lb./in.² to 70° F. at 14.4 lb./in.² abs.

V = volume of a mass M of fluid under consideration, cu. ft.

l = distance of a cross-section above an assumed datum plane, ft.

q = heat, in equivalent ft-lb. (or in B.t.u. × 778), imparted to 1 lb. of fluid from outside the fluid body.

z = mechanical energy, ft-lb./lb. of fluid, transformed into heat by frictional resistances. Symbol z, in equivalent ft-lb. (or in B.t.u. × 778) also represents the heat energy into which such mechanical work is transformed.

Subscripts 1 and 2 applied to any of the symbols denote conditions at an upstream cross-section F_1, and a downstream cross-section F_2, respectively. In the case here considered, the upstream cross-section is lower in elevation.

Consider a fluid flowing from section F_1 to section F_2 through a tube, as illustrated in fig. 14. The channel need not be vertical or uniform in cross-section, and sections F_1 and F_2 may be of different areas. For convenience, however, these end cross-sections are considered to be horizontal and at right angles to straight and vertical runs of the tube. The fluid under consideration is elastic, so it fills the tube completely, and no external forces except gravity act upon it between the two sections.

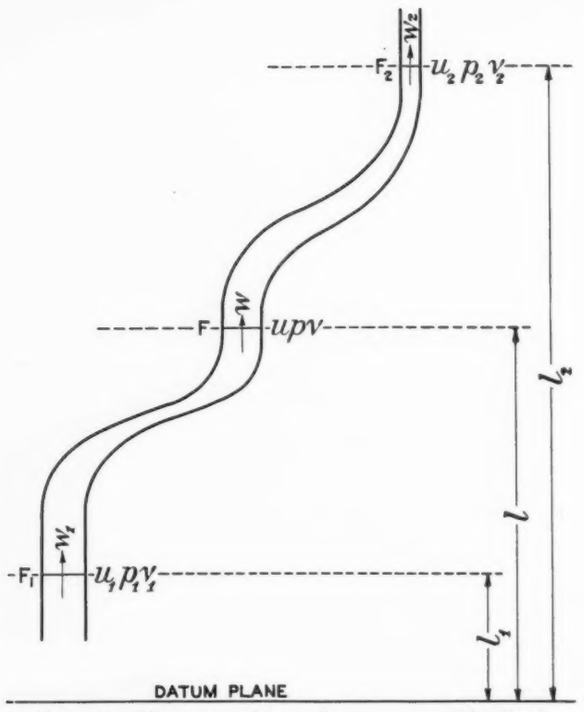


Fig. 14. Illustrating flow of a compressible fluid

To deal with a simple, hypothetical case, the following assumptions are made:

1. That the fluid is homogeneous.
2. That the flow is steady; that is, in a unit of time the same weight of fluid flows through every cross-section.
3. That the fluid flows with velocity w_1, in a direction at right angles to the plane of the cross-section, through every element of cross-section F_1; likewise with velocity w_2 through every element of cross-section F_2.

Since the flow is steady, 1 lb. of the fluid passes across each of sections F_1 and F_2 in the same interval of time. When 1 lb. of fluid passes the lower cross-section F_1 it carries with it the following energy:

u_1, its intrinsic energy, due to its temperature and the position of its molecules.

$\frac{w_1^2}{2g}$, its kinetic energy due to its upward velocity.

p_1v_1, which represents the mechanical work performed in forcing the lb. of fluid across section F_1. This is equivalent to the head of a column of fluid of uniform density $\frac{1}{v_1}$, which would give pressure p_1.

l_1, which is the potential energy (referred to the assumed datum plane) of the lb. of fluid due to the action of gravity upon it.

Drawing upon terms used in hydraulics, $\frac{w_1^2}{2g}$, p_1v_1, and l_1 may be called, respectively, the velocity head, pressure head, and potential head of the fluid at section F_1.

Under the conditions stipulated, the lb. of fluid receives no mechanical energy from external sources while passing from F_1 to F_2, but it may receive heat q from sources outside the fluid. In case the fluid loses heat, q has a negative value.

At section F_2, 1 lb. of fluid has the intrinsic energy u_2, the velocity head $\frac{w_2^2}{2g}$, the pressure head p_2v_2, and the potential head l_2.

Balancing all forms of energy and expressing quantities of heat in units of equivalent work, it is apparent that:

The intrinsic energy, velocity head, pressure head, and potential head of 1 lb. of fluid at section F_1, plus the heat per lb. of fluid imparted from external sources to the fluid between sections F_1 and F_2, equals the intrinsic energy, velocity head, pressure head, and potential head of 1 lb. of fluid at section F_2, or,

$$u_1 + \frac{w_1^2}{2g} + p_1v_1 + l_1 + q = u_2 + \frac{w_2^2}{2g} + p_2v_2 + l_2 \qquad (A)$$

Between sections F_1 and F_2 each lb. of fluid does the mechanical work $\int_{v_1}^{v_2} p\,dv$ upon the surrounding fluid, so each pound of fluid must receive that amount of work from the rest of the fluid between the two sections. Such work can be done only by converting the heat energy of the fluid into mechanical energy. Since the work and heat must be equivalent, $\int_{v_1}^{v_2} p\,dv$ is the measure, per lb. of flowing fluid, not only of the work received but also of the heat (expressed in equivalent work units) that was transformed into that work. It may therefore be considered that each lb. of fluid does the work $\int_{v_1}^{v_2} p\,dv$ upon itself at the expense of its own heat energy.

For each lb. of fluid flowing from section F_1 to section F_2 the mechanical work z done against frictional resistance is converted into the heat z (expressed in work units) that is absorbed by the fluid.

With these conceptions, and measuring heat in equivalent work units, a balance of heat (or nonmechanical) energy may be expressed as follows:

The intrinsic energy of 1 lb. of the fluid at section F_1, minus the heat energy per lb. of fluid transformed into mechanical work by expansion of the fluid between the two sections, plus the heat per lb. of fluid into which mechanical work is transformed in overcoming frictional resistance between the two sections, plus the heat per lb. of fluid imparted from external sources to the fluid between the two sections, is equal to the intrinsic energy of 1 lb. of fluid at section F_2, or,

$$u_1 - \int_{v_1}^{v_2} p\,dv + z + q = u_2 \quad - - - - - - \qquad (B)$$

Subtraction of equation (B) from equation (A) gives equation (C) shown below. Also, equation (C) may be developed by balancing mechanical energy as follows:

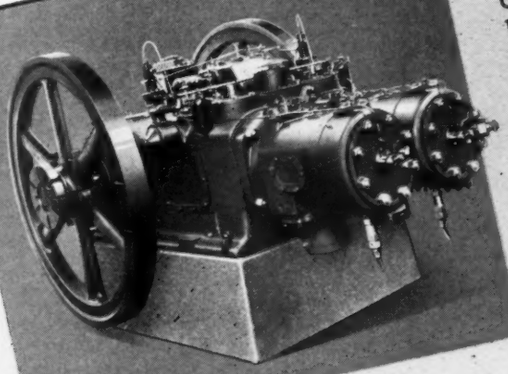
The velocity head, pressure head, and potential head of 1 lb. of fluid at section F_1, plus the work per lb. of fluid (derived from heat energy) done upon the fluid between the two sections, minus the mechanical energy per lb. of fluid converted into heat by frictional resistances between the two sections, is equal to the velocity head, pressure head, and potential head of 1 lb. of fluid at section F_2, or,

$$\frac{w_1^2}{2g} + p_1v_1 + l_1 + \int_{v_1}^{v_2} p\,dv - z = \frac{w_2^2}{2g} + p_2v_2 + l_2 \qquad (C)$$

Equation (C) may be written in the form:

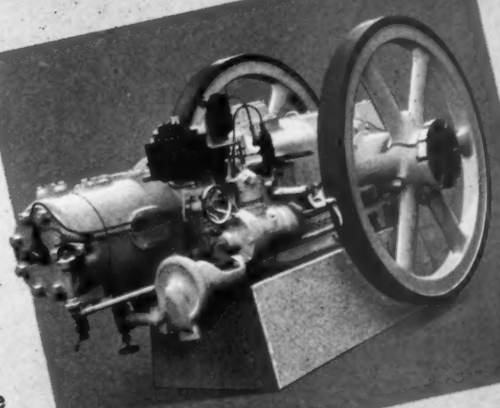
$$p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2 = (l_2 - l_1) + \frac{w_2^2 - w_1^2}{2g} + z \qquad (D)$$

All Diesels are Economical
These are *Simple* and *Reliable*



Left — The Cooper-Bessemer Type G-AW twin-cylinder Diesel rated 100 H. P. Has two-cycle simplicity. Can be converted to a gas engine.

Below — The Cooper-Bessemer Type G-AO single-cylinder, two-cycle Diesel rated 45 H. P. This engine can be converted to operate on gas.

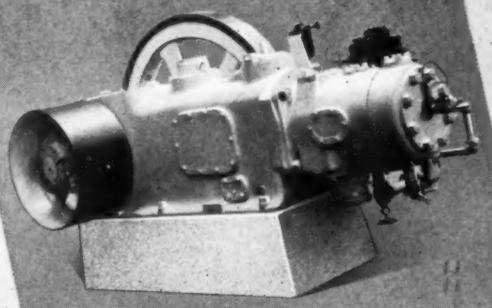


Cooper-Bessemer designed these Diesels to meet the special requirements of the oil fields.

The first requirement of a Diesel pumping engine is reliability. But, aside from that, these engines are so simple that no Diesel experience is required to operate them.

These engines will start in the coldest weather and are built for twenty-four hour continuous operation. Low maintenance costs are assured by such features as box type main frame, Timken main roller bearings, die forged crankshafts, drop forged connecting rods and fully automatic lubrication.

Write or call any of our branch offices for complete information on Cooper-Bessemer oil field Diesels. 25 to 1200 H.P.



Right — Type G-AO equipped with one heavy flywheel and belt pulley. This single has the same modern construction features as the larger twin. Both are cold starting full Diesels.

THE COOPER-BESSEMER CORPORATION

Mt. Vernon, Ohio — PLANTS — Grove City, Pennsylvania

640 East 61st Street, Los Angeles, Calif.
201 East First Street, Tulsa, Oklahoma
Magnolia Building, Dallas, Texas
25 West 43rd Street, New York City
225 Crockett Street, Shreveport, La.
505 Esperson Building, Houston, Texas

The expression to the left of the equality sign, which (as may be shown analytically or graphically, equals $-\int_{p_1}^{p_2} v\,dp = \int_{p_2}^{p_1} v\,dp$, may be represented by an area as shown in fig. 15.

Where the object of the flowing process is to lift fluid the expression $p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2 = -\int_{p_1}^{p_2} v\,dp$ (area *ABCF* of fig. 15) represents energy that may be drawn upon to do work, and the increase $(l_2 - l_1)$ in potential head of the fluid may be looked upon as useful work done. The increase $\frac{w_2^2 - w_1^2}{2g}$ in kinetic energy of the fluid and the mechanical energy z transformed into heat by frictional resistance represent losses. In a hypothetical frictionless, reversible process involving no increase in velocity of the fluid all the energy $p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2$ could be converted into the useful work $l_2 - l_1$.

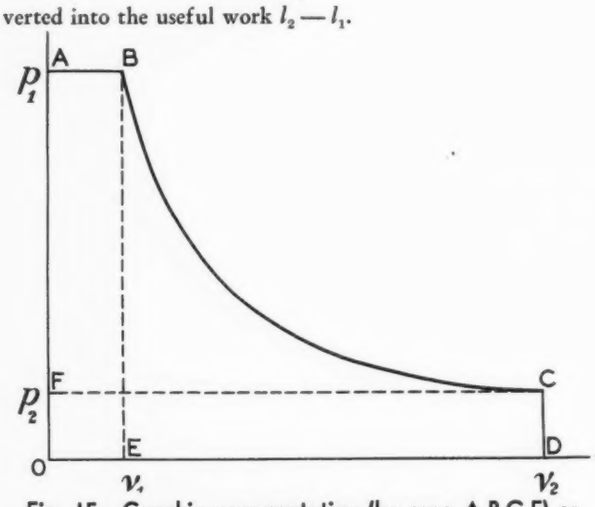


Fig. 15. Graphic representation (by area A B C F) or

$$p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2 = -\int_{p_1}^{p_2} v\,dp = \int_{p_2}^{p_1} v\,dp$$

If the pressures are expressed in lb./in.^{2}, P (instead of lb./ft.^{2}, p) and M lb. of fluid, of volume V, are under consideration the energy that may be drawn upon (M times the area *ABCF* of fig. 15,) is:

$$144\left(P_1V_1 + \int_{V_1}^{V_2} P\,dV - P_2V_2\right) = -144\int_{P_1}^{P_2} V\,dP.$$

Indicated Work of Bottom-Hole Sample

Considering the unit volume of fig. 12 to be 1 cu. ft., the area bounded by curve *A*, the vertical axis, and any two horizontal lines representing pressures, measured in units of 1 lb. $\times$ 1 cu. ft., is $P_1V_1 + \int_{V_1}^{V_2} P\,dV - P_2V_2$ for 1 cu. ft. of the bottom-hole oil measured at 2829 lb./in.^{2} abs. and 149° F. (45.8 lb. of fluid), where P_1 is the higher and P_2 the lower of the two pressures and V_1 and V_2 are the corresponding volumes of this quantity of fluid. Multiplication of this area by 144 gives a quantity of energy referred to 45.8 lb. of fluid, which corresponds to the expression $p_1v_1 + \int_{v_1}^{v_2} p\,dv - p_2v_2$ (area *ABCF* of fig. 15) referred to 1 lb. of fluid. Drawing on the relation of the areas here discussed to an indicator diagram, in the following discussion the quantity $144\left(P_1V_1 + \int_{V_1}^{V_2} P\,dV - P_2V_2\right) = -144\int_{P_1}^{P_2} V\,dP$ will be referred to as the indicated work of the fluid between pressures P_1 and P_2. For example, 144 times the area bounded by curve *B* (fig. 12), its vertical axis, and the horizontal lines representing the pressures of 2829 and 14.4 lb./in.^{2} abs. will be termed the indicated work of 1 cu. ft. of the bottom-hole oil, measured at 2829 lb./in.^{2} abs. and at 70° F. (47.8 lb. of fluid), between the reservoir pressure of 2829 lb./in^2 abs. and atmospheric pressure.

Although the fluid on which curve *A*, fig. 12, is based is "bottom-hole" rather than "reservoir" oil and the expansion during flow from the reservoir is not isothermal it will be of interest for purposes of illustration to determine the indicated work of this fluid expanding isothermally at the reservoir temperature of 149° F. between the following pressures:

(a) The reservoir pressure and pressure at the bottom of the hole when the well was flowing.

(b) The pressures at the bottom of the hole and wellhead when the well was flowing.

(c) This wellhead pressure and atmospheric pressure.

While the well was flowing at the rate of about 18 bbl. of residual oil per hour just before it was shut in for taking the bottom-hole sample the wellhead pressure was 894 lb./in.^{2} abs. The bottom-hole pressure during that period is not known, but the saturation pressure of 2575 lb./in.^{2} is believed to be a close approximation to it.

The area between the curve and the vertical axis (fig. 12) may be determined with a planimeter or by two methods that will be called, respectively, "mathematical" and "graphic" integration. Although measurement with a planimeter is convenient the other methods of determining the areas were employed in this investigation because of their greater accuracy and the use that may be made of the computations in clarifying certain parts of the discussion.

In mathematical integration either $\left(P_1V_1 + \int_{V_1}^{V_2} P\,dV - P_2V_2\right)$ or $-\int_{P_1}^{P_2} V\,dP$ may be used. In general, the use of $-\int_{P_1}^{P_2} V\,dP$ involves the smaller amount of computation, but the use of $P_1V_1 + \int_{V_1}^{V_2} P\,dV - P_2V_2$ is the more instructive because it indicates the relative importance of the work $144\,(P_1V_1 - P_2V_2)$ due to difference in pressure heads and the work $144\int_{V_1}^{V_2} P\,dV$ due to expansion of the fluid.

TYPICAL LUFKIN INSTALLATIONS

No Gear FAILURES ~a Lufkin Record

Lufkin installation in the Oklahoma City Field; Lufkin TC-0-56 Unit with 130-lb. Beam.

Lufkin TC-1A-58-1028-C Unit with 130-lb. Beam. Hercules engine. I. T. I. O. Corp., South Glendale No. 2, Oklahoma City.

Lufkin TC-2-26 Unit, Lorraine, Kansas. This photo not retouched—being entirely covered with ice gives retouching appearance.

T. C. Johnson Oil Co., Wichita, Kansas. Lufkin TC-3-22 Unit with G. E. enclosed motor.

Lufkin TC-5-7 Unit at County Line, Oklahoma.

Illustrated above are typical LUFKIN installations in the Kansas and Oklahoma City fields. For compact, heavy-duty pumping jobs, LUFKIN Units are prime favorites. Our Tulsa office is handy, 1305 Philtower Building, with an experienced field representative and service man in Oklahoma City.

The LUFKIN Record is—*No LUFKIN Herringbone Gear has ever failed in service.* This is a record we are proud of. And why shouldn't we be? It attests the fine workmanship and materials that go into the manufacture of LUFKIN Pumping Units, and is the reward of years of specialization in this particular branch of the oil industry. Close co-operation with oil company engineers and practical men in the field has resulted in a time-tested, trouble-free product of which we are justly proud. It is no unusual thing to hear oil men say "*You can't beat a LUFKIN.*"

SEE YOU AT THE INTERNATIONAL PETROLEUM EXPOSITION 1936 9TH WORLDS FAIR OF THE OIL INDUSTRY TULSA, U.S.A. MAY 16 TO 23

Lufkin Pumping Units are manufactured in Lufkin, Texas, by the LUFKIN FOUNDRY & MACHINE COMPANY. *Sales offices in* Houston, Tulsa, Dallas, Henderson, Odessa, Los Angeles, Bakersfield and New York City, N. Y.

LUFKIN CATALOG 36 — Lufkin's NEW No. 36 Catalog (reprinted in full in the Composite Catalog) contains complete specifications and blue print setting plans for all types of equipment manufactured by the Lufkin Foundry & Machine Company. This catalog will be gladly mailed to oil men anywhere, without obligation to buy. Write for your copy today!

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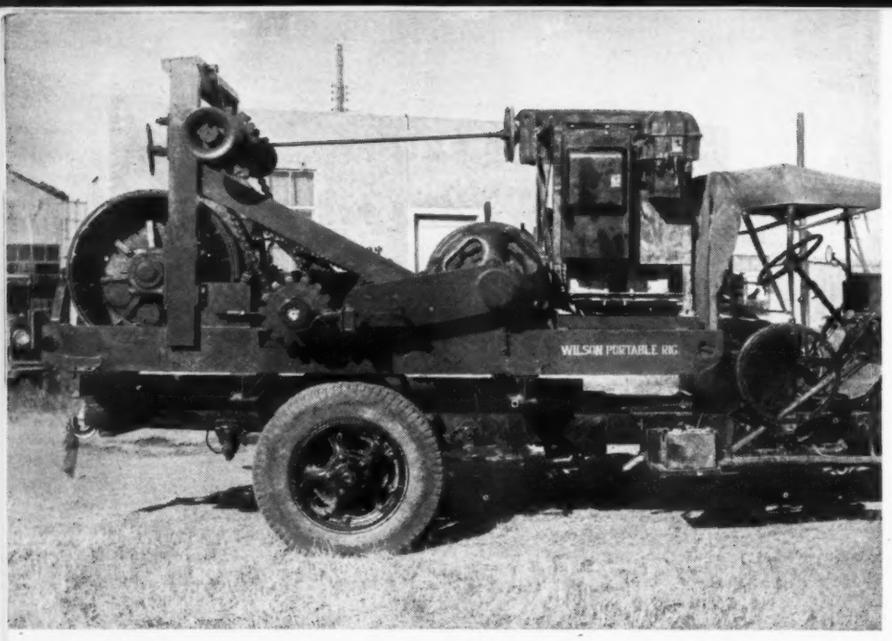


View showing the electric motor drive and electric controls mounted on steel skids

Current for Electric Motor Drive Supplied from Portable Oilfield Substation—Rigging-Up Time Reduced by Standard Set-Up at Location

Modern Electric Portable Rotary Rig

By T. B. FLOOD

ONE of the large operators in West Texas required a rotary rig to drill to depths of approximately 3000 ft. and also for special work such as drilling-in under pressure, deepening old wells, and for use on special fishing jobs. It was desired to have a rig that was of light weight, readily portable, and of sufficient capacity for 3000-ft. rotary work.

With these requirements in mind, a rig designed and constructed for the desired service was obtained. As electric power was available in the fields where it was intended to use this unit, it was equipped with 440-volt a-c. motors.

The complete rotary rig consists of: A drawworks and transmission with a 25/65-hp. protected type motor and control mounted on steel skids. The unit is housed with a steel frame and corrugated iron sheathing. The weight of this rig is about 14,000 pounds. If desired, the unit can be removed from the truck and placed on a wooden foundation.

Two pumps are used, one 7¼ by 14 (6-in. liners) and the other 5⅞ by 12; they are driven by 25/65-hp. motors and are mounted on steel frames. The controls for both pumps, together with the small transformers and miscellaneous switches, are installed in a small portable house.

The main transformers and the switching and meter equipment are supplied by the power company, and are mounted on a trailer. When in use, this transformer unit is protected by a fence (see illustration below).

Since these various main units are either mounted on a truck or on separate skids, only a minimum amount of rigging-up time is required. To increase further the efficiency of this operation, the pits and all the various pieces of equipment are always placed in relatively the same position at each new location. This arrangement simplifies the necessary piping and connection work.

Experience shows that the actual drilling time is about comparable with the ordinary rotary rig and there has been only a small amount of shut-down time for repairs of the machinery and electrical equipment.

For the first 2400 ft. of hole, 5-in., 20.5-lb. drill pipe is used; thereafter, a string of 2⅞-in. drill pipe is used to complete the wells.

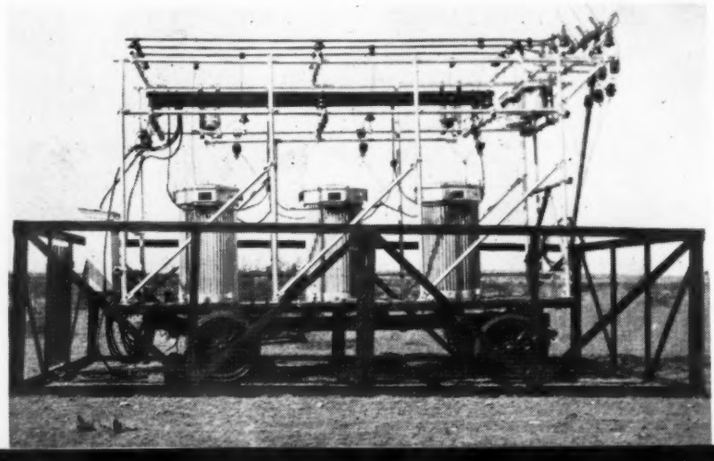
The 25/65-hp. drawworks motor has proven satisfactory for this work and pipe is handled with reasonable speed.

This unit has been used for drilling in the following West Texas fields within the past two years:

Yates Field	Depth approximately 1400 ft.
Eastern Howard County	Depth approximately 2850 ft.
Powell Field, Crockett County	Depth approximately 2550 ft.

The power consumption, of course, varies in the different fields, according to the formation encountered. The average drilling time and the kw-hr. consumption per well for the different fields are as follows:

Here is shown the portable oilfield sub-station of the Texas Electric Service Company in use in West Texas. It consists of three 100-Kva. 12,500 to 400 volt transformers complete with primary metering equipment, lightning arrestors, and air switches.



This portable sub-station greatly reduces the cost of line extensions to serve drilling rigs and can be moved from one location to another in a very short time. Even the surrounding fence can be knocked down and assembled to form the sides of the truck in a few minutes.

International Model C-55-F dual-drive six-wheeler used by Guy Nall, Seminole, Okla., for heavy-duty hauling in the fields.

There Is a Complete Line of International Six-Wheel Trucks—in Trailing-Axle and Dual-Drive Types

INTERNATIONAL Six-Wheel Trucks are available in two types, one driving on all four rear wheels and the other employing a trailing axle and driving on the two forward wheels of the rear axle group. Both types offer important advantages for service under unusually severe operating conditions. Among the more important of these, as compared to the conventional type of vehicle, are: (1) greater payload in proportion to truck weight; (2) better load distribution; (3) substantial economies in tire, fuel, and lubrication expense; (4) longer life, with lower maintenance costs; (5) easier handling and safer operation; (6) improved riding qualities; and (7) wider economical operating range due to larger payloads made possible by higher maximum weight limits permitted by road laws.

See the nearest Company-owned branch, or International dealer, for complete information on the International Six-Wheelers, and the full line of four-wheel trucks.

INTERNATIONAL HARVESTER COMPANY
(Incorporated)
606 So. Michigan Ave. Chicago, Illinois

This illustration shows the flexibility of the International six-wheel mounting, which allows free up and down movement of the four rear wheels.

•

There are seven International models of the trailing-axle type. Two of them — Models CS-35-T and CS-40-T — are available with two-speed rear axles. There are three models of the dual-drive type—Models C-40-F, C-50-F, and C-55-F—each of which is regularly equipped with auxiliary over-drive and under-drive transmissions.

INTERNATIONAL HARVESTER

View of the drawworks showing the controls of the portable rig

Average Drilling Time and Kw-hr. Consumption

	Drilling time days	*Total kw-hr.*	*Kw-hr. per day*	*Kw-hr. per ft.*
Yates—Pecos County	19	8040	423	5.5
Eastern Howard County	34	28603	841	10.0
Powell Field, Crockett County	26	30080	1157	11.8

For the work intended the rig has proven satisfactory for the following reasons:

1. It is light in weight and the first cost is low.
2. It is readily portable and the various units are so arranged that they are easily transported and easily installed.
3. The arrangement mentioned herein reduced rigging-up time to the minimum.
4. Repairs and maintenance have not been costly.
5. Few power interruptions have been experienced and no serious delays have occurred from this source.

As in any operating equipment, certain disadvantages have been noted. From the writer's personal observation, these are:

1. The motor and control are mounted directly behind the drawworks and in close proximity to the well. Motor brushes are enclosed in an explosion-proof case and the switches operate in oil; however, at times the grids on the control get very hot and if any gas is escaping, a serious fire hazard is set up.
2. The power interruption might be serious at certain times if circulation could not be maintained or if the drill pipe could not be moved. A stand-by unit of some type would be desirable.

These two objections may be overcome—when they are, much of the criticism of electric rigs of the type discussed herein will be eliminated.

Petroleum Sessions to Be a Feature of Mineral Industries Conference of Illinois

Of special interest to those identified with the oil and gas industry is the program of the fourth annual Mineral Industries Conference of Illinois, to be held at Urbana, on April 24 and 25, under the joint auspices of the Geological Survey Division of the State Department of Registration and Education, the Engineering Experiment Station of the University of Illinois, and the Illinois Mineral Industries Committees.

Having for its central theme current and needed additional researches for Illinois mineral industries, the conference will be of the open forum discussion type, with separate sessions scheduled for the several individual industrial groups represented at the meetings.

At the forum on oil and gas research, on Friday afternoon, demonstrations of the results of current researches will be presented. The symposium on needed researches for the oil and gas industry, scheduled for Saturday morning, will provide ample opportunity for everyone interested in oil and gas research to present his own ideas and suggestions regarding studies now in progress and those that might well be undertaken in the future for the benefit of the industry.

The preliminary program for the oil and gas sessions follows:

Friday, April 24, 2:00 p.m.

FORUM ON OIL AND GAS RESEARCH

305 Ceramics Building

Leader, A. H. Bell, Illinois State Geological Survey

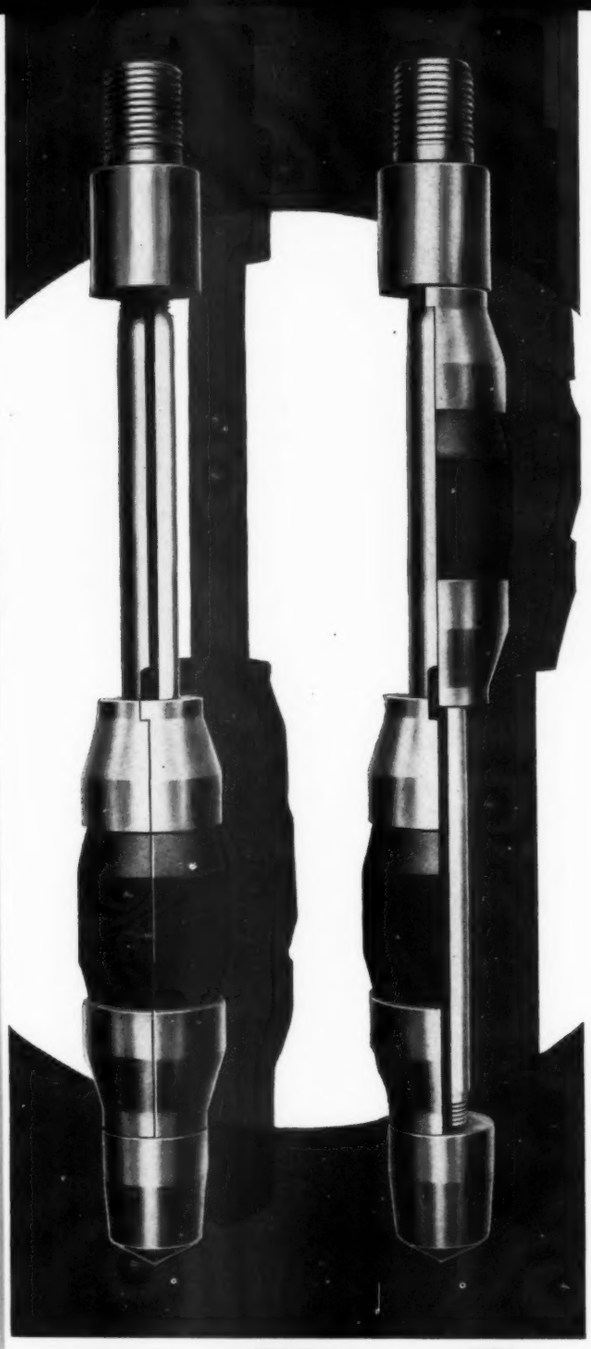
1. Researches on the underground geology of Illinois, L. E. Workman, associate geologist, Illinois State Geological Survey.
2. Studies of outcropping strata in the Illinois basin, J. M. Weller, geologist, Illinois State Geological Survey.
3. Flow of fluids through "oil sands," R. J. Piersol, physicist, Illinois State Geological Survey.
4. Studies of repressuring and water flooding, A. H. Bell, geologist, Illinois State Geological Survey.
5. Training in petroleum engineering, R. Larson, associate in mechanical engineering, University of Illinois.

Saturday, April 25, 9:30 a. m.

SYMPOSIUM

Chairman, William Bell, president, Illinois-Indiana Petroleum Association, Robinson, Illinois

1. A comprehensive survey of reserves and underground conditions in Illinois oil fields, William Bell, president, Illinois-Indiana Petroleum Association.
2. Problems in improved oil recovery, Millard Flood, engineer, Ohio Oil Company, Marshall, Illinois.
3. The permeability of oil sands in relation to improved recovery, W. S. Corwin, manager, Tide Water Oil Company, Robinson, Illinois.
4. Present status and future possibilities of acid treatment in Illinois fields, speaker to be announced.
5. Relation of imports and exports of petroleum to the domestic industry, W. H. Voskull, mineral economist, Illinois State Geological Survey.



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FASTEST FALLING SWAB ON THE MARKET

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NO BALL AND SEAT VALVES TO GET OUT OF ORDER . . .

WEAR ON SWABBING RUBBERS REDUCED

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FAST FALLING SAVES MANY HOURS OF WORK IN DIFFICULT SWABBING JOBS

SEE YOU AT THE INTERNATIONAL PETROLEUM EXPOSITION 1936
9TH WORLDS FAIR OF THE OIL INDUSTRY TULSA, U.S.A. MAY 16 TO 23

» SAVE MONEY BECAUSE OF FAST ROUND TRIPS «

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MISSION SLIPS . . . . MISSION VALVES . . . . MISSION PISTONS . . . . MISSION SWABS

General view of new East Texas gasoline plant of Gilliland General Gasoline Company

East Texas' Newest Gasoline Plant is of Compression and Hot-Rectification Type

Casinghead gas from 850 wells, and vapors from a refinery at Overton, being processed. Plant so designed that later, with the addition of equipment, it also can be used for extraction of butane

By FRANK H. LOVE

THE most recent addition to East Texas' ever-increasing number of natural gasoline plants is that of the Gilliland General Gasoline Company, of which J. W. Gilliland, Gladewater, Texas, is president. Situated between Overton and Kilgore, the plant is on the Tide Water Oil Company's Jernigan lease, W. W. Simms Survey, in Rusk County. It is of the compression and hot-rectification type, and has been so designed that later, with a minimum of additional equipment, it also can be employed for the extraction of butane.

Although processing 10,000,000 cu. ft. of casinghead gas daily at present, all auxiliary equipment, such as coolers, pumps, fractionating towers, water cooling towers, etc., has sufficient capacity for the handling of 15,000,000 cu. ft., and all that is required to increase the capacity of the plant to that volume is the addition of the necessary compressor units. That the capacity likely will be augmented at an early date is indicated by the fact that, although connections now are made with 850 wells, it is expected this number will be boosted to 1000 within 30 days. In addition to that source of gas supply, vapors are received from the Overton refinery of the company, being handled separately from the field gas and caustic-washed prior to processing.

The nine 230-hp. compressor units, which boost the gas pressure in two stages, are of the latest design. Each has a capacity of 1,300,000 cu. ft. daily at 10 in. of vacuum. The gas is discharged at a pressure of 275 pounds. Mufflers have been placed on the exhausts of these units to minimize noise.

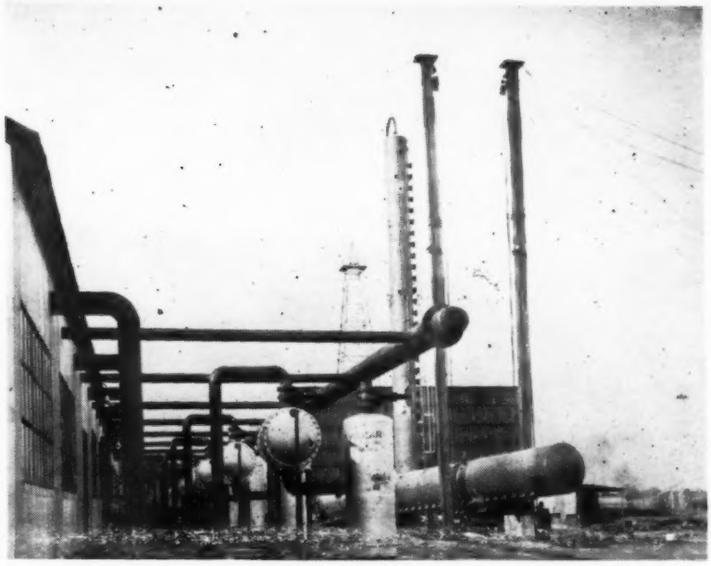
The fractionating towers, primary and secondary, are designed to operate efficiently over a range of 8,000,000 cu. ft. to 15,000,000 cu. ft. of gas daily, each having 30 trays. The primary tower is 6 ft. by 66 ft. and has a working pressure of 275 lb., the secondary tower being 4 ft. by 66 ft. with a working pressure of 200 pounds.

Two cooling towers, one for engine water, the other for process water, are of the atmospheric type, natural draft, each having a capacity of 1200 gal. per minute.

Auxiliary equipment consists of a 125-hp. twin gas engine driving, by means of a V-belt, a 75-kw. generator to provide electricity with which to power the water pumps and air compressor, and for lighting purposes. Water pumps are of the centrifugal type each having a capacity of 1200 gal. per minute. The air compressor builds up pressure in nine horizontal starting air tanks situated out-of-doors, but near the station building, approximately 250 lb. of air being required to start the gas compressor units. All controllers also are operated by air pressure obtained from this same source.

Pumps provided, in addition to the water pumps already mentioned, are four piston-type close-clearance units, 12 by 8 by 18, 8 by 8 by 18, 10 by 8 by 18, and 8 by 6 by 12, and are utilized for pumping gasoline, as well as reflux to the two fractionating columns.

One 103-hp. and two 90-hp. high-pressure boilers provide



Showing the gas piping, inter-stage scrubbers and coolers, primary fractionating tower (on ground ready to be erected), secondary fractionating tower (erected), and, in the background, the process water cooling tower.

the steam required in the operation of the plant.

Automatic features, with centralized control, have been installed throughout the plant. One of the interesting automatic devices is a liquid-level controller with mercoid switches, placed on the incoming gas scrubbers, designed to shut down the compressor units in event a "slug" of crude oil should be received from the field.

Engine and auxiliary rooms are under one roof with a vapor-tight wall between. The main building is of structural steel, 36 ft. by 200 ft., and has concrete floors. Additional buildings within the plant grounds include a 24 ft. by 36 ft. warehouse of structural steel, a frame office building, 24 ft. by 38 ft., and a frame laboratory building, 14 ft. by 18 ft., is being erected. The latter will have complete gas fractional apparatus, in addition to its other equipment.

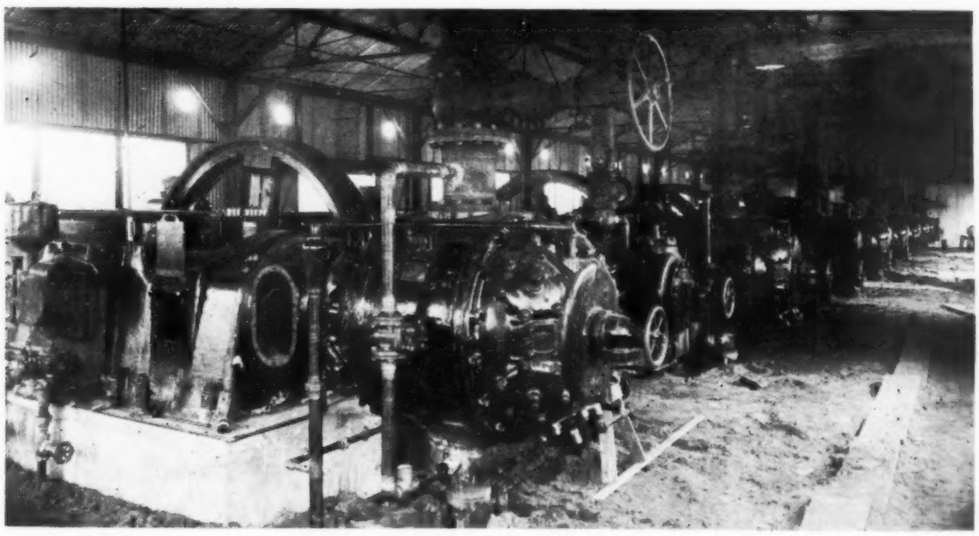
Conditions existing in the East Texas field necessitate a gathering and residue system of unusually large diameter and capacity. The system is designed to cope with flowing conditions resulting from well proration and has a 100 percent over-capacity. A very definite flowing schedule also must be followed in order to obtain a steady flow of gas to the plant, since each well is produced but a few minutes each day.

To connect the 850 wells, 92 miles of gathering and residue lines have been laid, ranging in size from 16 in. down to 5 in. in diameter. The field system has been constructed of pipe of sufficient diameter to maintain 4 in. of vacuum at the extreme end, with a 100 percent overload. Five main gathering lines carry the gas to the plant, and each is paralleled with a 6-in. residue line. Residue gas is returned to the leases, where it is utilized for drilling purposes, the operation of leases, and in the future may be used for gas-lift. Residue laterals to the leases are of 2½-in. and 4-in. pipe. The entire residue system, including all valves and fittings, is designed for 275-lb. working pressure. The large diameter gathering and residue lines necessitate a corresponding oversize in the scrubbers on the intake and outlet headers. The two intake scrubbers are 8 ft. by 30 ft. and the outlet scrubbers 5 ft. by 16 feet.

The casinghead gas is sweet and requires no treating; however, as previously mentioned, it is necessary to caustic-wash the refinery vapors received from Overton. A natural gasoline ranging from 12 lb. to 26 lb. Reid vapor pressure is being manufactured, although the equipment is capable of processing a 45-lb. product should the market demand make it advisable. Storage tanks totaling 100,000 gal. in capacity have been provided, from which the finished stock is transmitted by means of a 12 by 8 by 18 close-clearance steam pump, and through a 4-in. pipe line, to the Gilliland refineries at Overton and Gladewater where it is used for blending purposes.

C. W. Warwick is general superintendent of gasoline plants for the Gilliland General Gasoline Company, and D. L. Edmondson is designing engineer. R. S. Hancock is superintendent of the new plant, with E. L. Henry the office manager.

The plant is equipped with nine 230-hp. compressor units



Vacuum Equipment in the Oil Refinery

Part 3

By CHARLES T. CHAVE

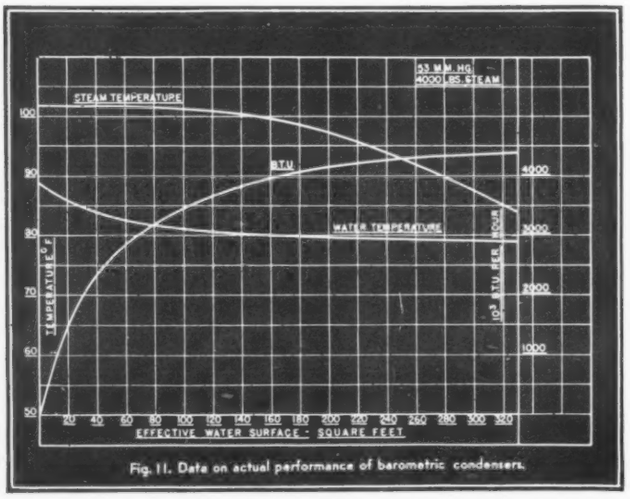


Fig. 11. Data on actual performance of barometric condensers.

THE actual mechanics of condensation may be described as a migration of vapor molecules from a region of high partial pressure existing in the main stream of the gas and vapor mixture, to a region of low partial pressure existing on the water surface. This transfer of particles is directly proportional to the partial pressure difference existing between these two regions, and not the temperature difference.

The mass transfer rate has been expressed by Colburn and Hougen as follows:

$$K = 80\ \frac{V^{0.8}F}{Mg^{0.5}Pg}$$

The above is for turbulent flow. In this formula,

V = mass velocity, lb. per sec. per sq. ft.
Pg = partial pressure of the gas.
Mg = molecular weight of the gas.
F = "entrance factor" for tubular equipment.
$F = 1 + 1.6\ (10^{-0.1N})$ for tubular equipment.
N = ratio of length of tubes to outside diameter.
K = lb./hr. × sq. ft. × in. Hg.

For viscous flow, below the critical velocity:

$$Vt = \frac{0.1\ (Mg)^{0.6}}{(29)F^{1.25}}$$

$$K = 2.36/Pg$$

Let us now consider a typical problem using these data.

Required to handle in a barometric condenser:

5000 lb./hr. steam
100 lb./hr. gas, 30 mol weight = 3.33 mols
70 °F water
40 mm. Hg

1. Outlet water temp. assuming 5° F. "Terminal Difference"

Saturation temp. at 40 mm. Hg	= 93° F.
Terminal difference	= 5° F.
Outlet water temperature	= 88° F.
Rise in water temperature	= 18° F.

2. Heat balance

B.t.u./lb. steam at 40 mm., saturated	= 1101.4
B.t.u./lb. water at 88 deg. fahr.	= 56.0
B.t.u./lb. steam condensed	= 1045.4

$1045.4 \times 5000 = 5230000$ Heat in steam

$100 \times (93—73) \times 0.50^{*} = 1000$ Heat in gas. Neglect.

3. Water quantity $= \frac{5230000}{18 \times 500}$

= 580 gal./min. or 290000 lb./hr.

Assume that we have an initial velocity of 25 ft./sec.

At 93°F, we have $\frac{359}{18} \times \frac{760}{40} \times \frac{460 + 93}{492}$

= 426 cu. ft./lb.

Mass velocity is then $\frac{25}{426} = 0.0582$. This corresponds to a flow area of 23.7 sq. ft., or 5 ft. 6 in. diameter.

Assuming water streams ¼ in. dia. × 1 ft. long as "tubes",

$F = 1 + 1.6\ (10^{-0.1 \times 48})$, or $F = 1.53$.

Since F approaches a low value of 1, assume 1.50 as a likely value.

$$Vt = \frac{0.1\,(Mg)^{0.6}}{(29)F^{1.25}} = \frac{0.1\,(30)^{0.6}}{(29)\,1.50^{1.25}} = 0.0587.$$

Hence we have viscous flow condition as soon as condensation sets in.

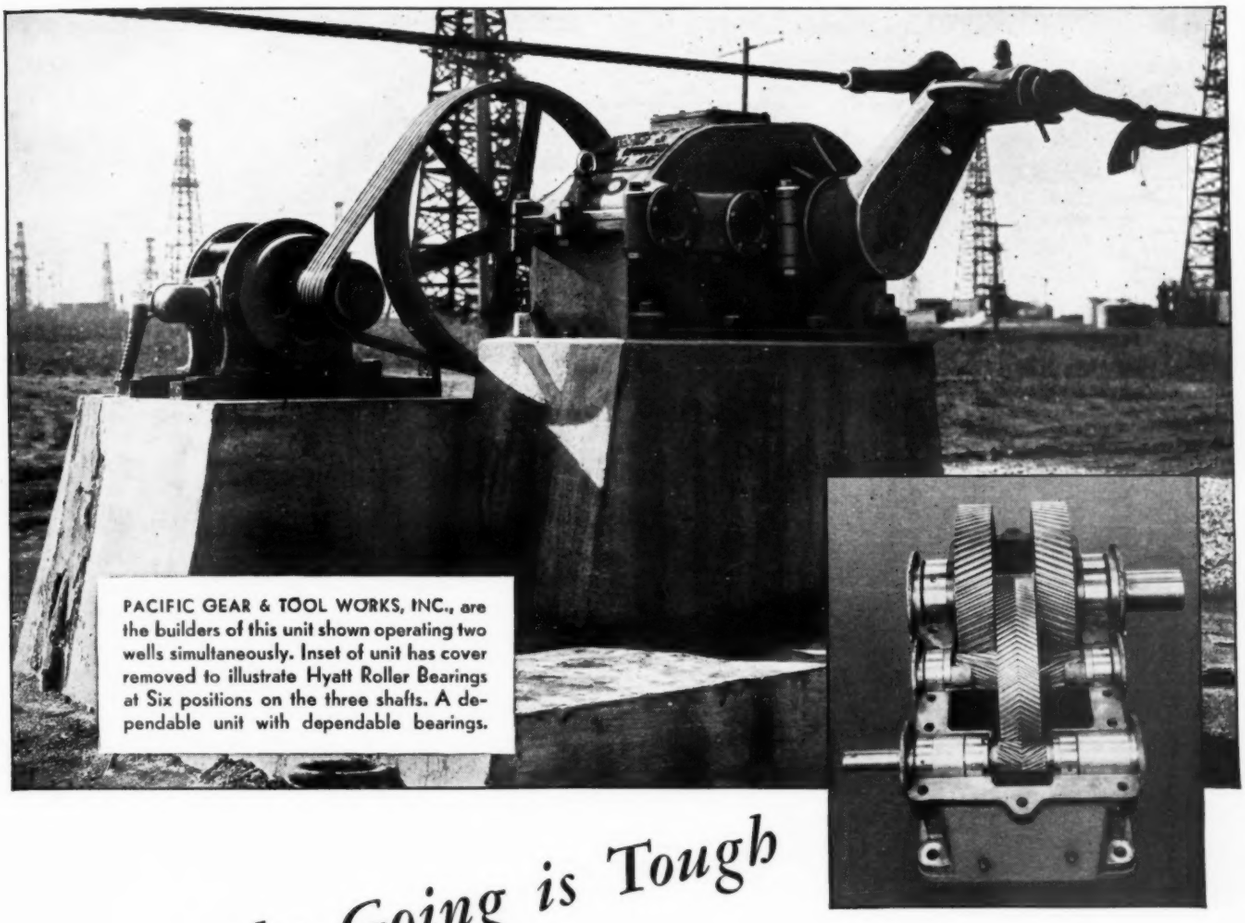
4. First 60 percent of condensing. Tabulation by zones of equal heat transferred.

Zone	1	2	3
B.t.u./hr	1,040,000	1,040,000	1,040,000
Lb./hr. condensed	1,000	1,000	1,000
Lb./hr. flowing	4,500	3,500	2,500
Mols flowing (Steam)	250	194	139
Mols of gas and steam	253.3	197.3	142.3
Partial pr. of steam, mm	39.6	39.3	39
Partial pr. of gas, mm	0.527	0.675	0.931
Temp. of steam	93	93	93
Temp. of water (mean)	86.2	82.6	79
Mass Transfer, K	4.47	3.5	2.52
Vapor pr. of water, mm	32	28.5	25.2
Partial pr. of diff., mm	7.6	11.8	13.8
Lb. per hr. x sq. ft.	34.0	37.8	34.8
Sq. ft. required	29.4	26.5	28.7

K =2.36/Pg.

5. Last 60 percent of condensing. Tabulation by zones of temperature drop.

In order to design for 345.8 sq. ft. of surface, we need a circular curtain, averaging 4 ft. in diameter, falling about 14 feet. Both sides are effective. With a condenser 5 ft. 6 in. in diameter, we get a job 5 ft. 6 in. x 16 ft. high, which is quite in line with a commercial size. A number of cascades, say two to three ft. apart are required to mix water up and prevent contraction of the curtain.



PACIFIC GEAR & TOOL WORKS, INC., are the builders of this unit shown operating two wells simultaneously. Inset of unit has cover removed to illustrate Hyatt Roller Bearings at Six positions on the three shafts. A dependable unit with dependable bearings.

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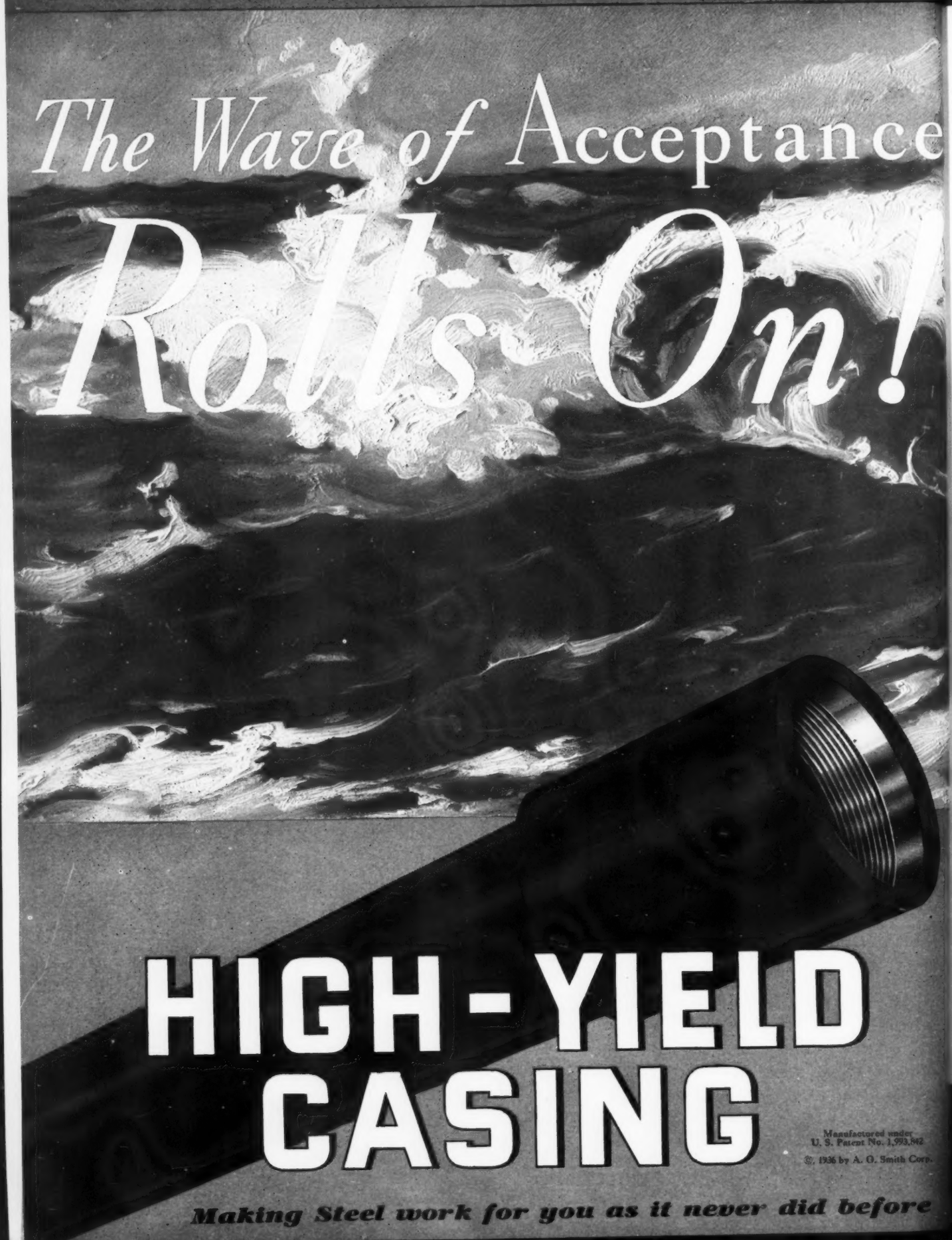

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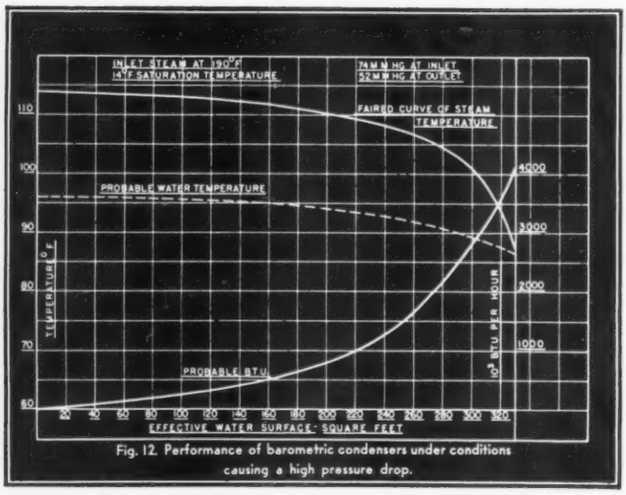


Fig. 12. Performance of barometric condensers under conditions causing a high pressure drop.

Assuming we had turbulent flow in the air-cooling section, say 100 cu. ft./sec. velocity, or 0.235 lb. per sec. per sq. ft:

$$K = \frac{80\ V^{0.8}F}{Mg^{0.5}Pg} = \frac{80 \times 0.313 \times 1.50}{5.48} = \frac{6.89}{Pg}$$

The surface of zones 6 to 9, totaling 169 sq. ft., could now be cut to $137.7 \times \frac{2.36}{6.89} = 47.7$ sq. feet. Referring to Fig. 10-A, in which the saturated gas is caused to pass through a short curtain of water at a high velocity, we could, perhaps, get an even better reduction in the total size of the condenser by this practice. The heat transfer at this point may be determined only by empirical means. On the other hand, a design of this character is not suitable for high overloads. If non-condensable gas, superheated steam and a large proportion of oil vapors enter the condenser, the diffusion rate in the lower section is greatly reduced. As a result, large volumes of steam try to pass through the small openings with a very high pressure drop.

The basis of design given above is perhaps pure conjecture. This design calls for about 350 Φ. This is a condensing rate of 14 lb. per hour per Φ. The volume is 380 cu. feet. This is 13.2 lb. of steam per cu. foot. The writer has seen a condenser of the same general design, condensing exactly 20 lb. per "theoretical square foot." The volume rate was nearer 75 lb. per cu. foot. As a consequence, the "terminal difference" and the "approach" were not so good as predicted herein, since the surface was not all effective.

The following table gives commercial practice in design for a barometric condenser. These data are submitted to show the bids submitted to cover one definite performance requirements:

Ratio steam to dry gas, by weight, at inlet, 16.1
Injection water temperature 68 deg. fahrenheit
Absolute pressure = 33 mm.

Type of Condenser	*Lb. Steam/hr. x cu. ft.*	*Approach*	*Terminal Difference*
As per Fig. 10-B	13.82	5° F.	7° F.
As per Fig. 10-B	12.8	------	------
As per Fig. 10-A	18.2	5° F.	9° F.
As per Fig. 10-C	46.7	3° F.	4° F.
Spray type, with multiple nozzles	34.6	5° F.	8° F.

The effect of the method of water distribution on the physical size of the condenser is great. A lesser effect on the price is to be observed, since the spray nozzles are inherently expensive.

Figs. 9, 11, and 12 show the comparison of the proposed design and an actual commercial installation tested by the writer. It may be seen in Fig. 9, derived from the theoretical design, and Fig. 11, that there is normally heavy condensation of steam in the bottom of the condenser. Comparison of temperature gradients indicates this clearly. In Fig. 12 is shown the performance of the commercial unit when light oil was entering the condenser with the steam. Practically no condensation occurs in the lower section. In the air-cooler section the steam velocity was so great that 25 mm. pressure drop occurred. When handling a normal amount of gas, this condenser operated with no pressure drop. The abscissae of these charts are multiplied by a factor to prevent identification of the actual data source.

From these observations it would appear that no commercial barometric condenser is entirely satisfactory. A design utilizing sheets of water in the lower section, where heavy condensation occurs, and using a spray in the air

5. Last 40 per cent of condensing. Tabulation by zones of temperature drop.

Zone	4	5	6	7	8	9
Temp. °F	93–90	90–87	87–84	84–81	81–78	78–75
Vapor pr. steam at low temp	36	32.8	29.8	27.0	24.6	22.1
Percent of total pr	90%	82%	74.5%	67.5%	61.5%	55.2%
Mols/hr. steam at low temp	30	15.1	9.76	6.90	5.33	4.10
Lb./hr. steam	2000–540	540–272	272–176	176–124	124–95.8	8–73.9
Lb./hr. condensed	1460	268	96	52	28.2	21.9
B.t.u./hr	1590 000	295 000	106 000	57 300	31 000	24 000
Temp. water	77.2	71.7	70.7	70.3	70.1	70.1–70
Lb./hr. steam, mean	1270	406	224	150	110	85
Mols, mean (steam)	70.5	22.6	12.4	8.33	6.10	4.72
Mols, total	73.83	25.93	15.73	11.66	9.43	8.05
Pg, mean, mm	1.8	5.13	8.45	11.4	14.1	16.5
K	1.31	0.460	0.279	0.207	0.167	0.143
Vapor pr. water, mm	21.7	20	19	18.8	18.8	18.8
Partial pr. diff., mm	14.3	12.8	10.8	8.2	5.8	3.3
Lb./hr. per sq. ft	18.7	5.9	3.1	1.7	0.97	0.472
Sq. ft. required	78.0	45.3	31.5	30.6	29.1	46.5
MTD	17°F	16.8°F	14.8°F	12.2°F	9.4°F	6.5°F
B.t.u./hr./sq. ft./°F.	1200	386	226	154	110	79.3

A total of 345.8 sq. ft. of surface is required, on the basis of a velocity below turbulent flow all the way through the condenser. The terminal "MTD" is 5° F. Based on this,

$$U = \frac{5230\ 000}{345.8 \times 5} = 3030$$

This transfer rate for steam to water is decidedly in line with expectations.

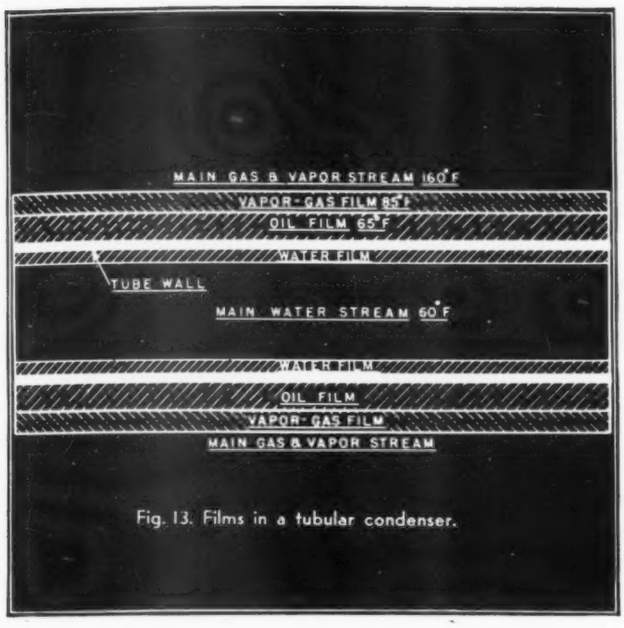


Fig. 13. Films in a tubular condenser.

cooler section might prove more satisfactory. The pressure drop in the air-cooler section would be eliminated, and a low heat transfer rate could be overcome by means of a large exposed surface. It has been claimed that, in a heavy duty condensing zone, fine spray tends partially to evaporate due to the low conductivity of small droplets, resulting in instability of operation. The low amount of heat absorbed in the air-cooler section would make this a matter of no concern. In the lower section of the condenser, stable sheets of water, remixed at proper intervals, would absorb the bulk of the heat.

It is natural that such an undeveloped subject should make trouble shooting a difficult matter. An understanding of the principles involved will lead the refiner out of many operating difficulties. The writer has from time to time investigated complaints from refinery operators concerning vacuum equipment. A few of these typical troubles are discussed in order to show the application of these principles:

1. *Oil in the discharge water.* This is often blamed on mechanical entrainment. As a matter of fact, it is usually due to saturation of the steam with the overhead product. In a tubular condenser equilibrium condensation does not occur. The oil is sub-cooled 30 deg. fahr. to 70 deg. fahr. below the temperature of the steam leaving the tubular unit. If the oil temperature is brought low enough to eliminate oil "carry over" to the barometric, it frequently results in the condensation of the steam in the oil. On the other hand, if the oil temperature is raised high enough to eliminate water in the product, the steam becomes hot enough to take up considerable oil in saturation. Fig. 13 illustrates the mechanics of condensation. The resistant films are shown. It is possible, if saturation temperature of the steam is 90 deg. fahr., for some steam to condense from the vapor-gas film, even though the main body is only cooled to 160 deg. fahrenheit. Cold water intensifies this effect.

In design, a large tubular condenser designed for warm water, and operating in a low "MTD" will reduce this effect.

In practice, it is always necessary to choose between the two evils, (provided that the surface condenser is large enough, to begin with). With a light gas oil, it is better to condense water in the oil, since separation is not difficult. With a cracked gas oil, 12 deg. to 15 deg. A.P.I., distilled from cracking still tar, it is better to keep the product dry, since separation is impossible. If the barometric water is recirculated over a cooling tower, the oil in the water is rapidly concentrated until it reaches nuisance proportions. The writer has found that a highly alkaline water forms with the oil an emulsion that floats, and that if this emulsion is continuously skimmed the nuisance is greatly reduced. The emulsion formed must be properly disposed of: i. e., either broken by long time settling in a heated tank, or burned. It will not be caught by an oil trap, and should not be put in the sewer system.

Fig. 14 shows a special feature (patent applied for) of a new type of unit condenser. Oil is circulated over a bubble tray, and steam, on the way to the barometric, is passed through it. This cold oil acts as an absorbing and condensing agent, reducing entrained and saturated oil in the steam, as well as superheat. This device has proven beneficial on several installations where baffles and other schemes were of no use whatever.

2. *Hunting of the ejectors.* It is a common fault of many operators to use too much inter-condenser water and flood the secondary stage. About 15 deg. to 20 deg. rise should be taken on this water.

Overloading also will cause serious hunting. The system should be examined for the following causes of overloading:

a. Leaks.
b. Unusually high still temperature.
c. Low initial on the overhead product.
d. High air content of the condenser injection water.

3. *Sudden loss of vacuum.* The most usual cause of this is a drop in steam pressure. The effects of this on ejector performance have been described above.

4. *Gradual reduction of vacuum, over a period of several months.* Dirt in the nozzles and steam strainers is the usual cause. The writer has known this to happen due to corrosion of the ejectors with some crudes. The throats and nozzles, if removable, must be renewed. Durion and KA_2 should be used for such cases.

5. *Little improvement in vacuum due to increased circulating water or lower temperature circulating water.* The ejectors control the vacuum. Referring to Fig. 7, it may be

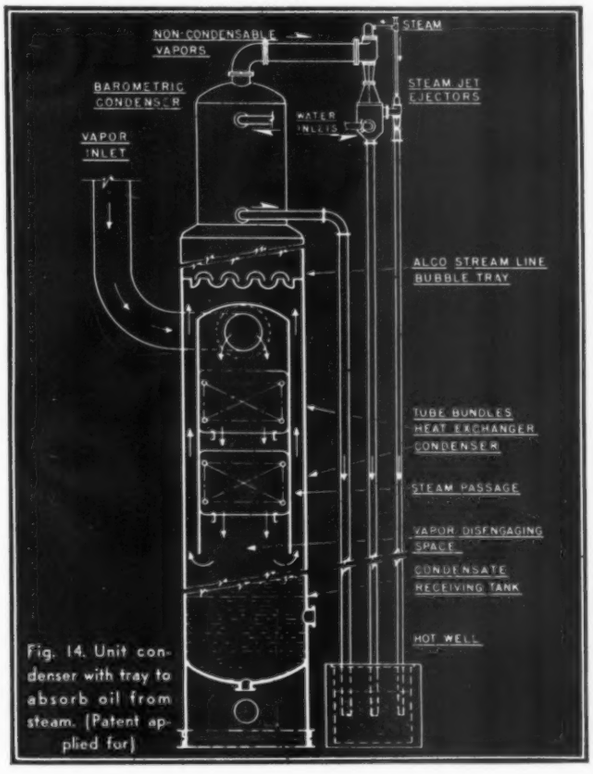


Fig. 14. Unit condenser with tray to absorb oil from steam. (Patent applied for)

seen that there is a "dead shut off" point, below which the ejectors cannot maintain the absolute pressure. Hence, in a system designed to run at 45 mm., for example, water double the amount of circulating water might not reduce the absolute pressure to below 40 mm. This fact becomes more pronounced when the ejectors fail to function properly. Even freezing water might fail to give 25 mm. absolute pressure, although the possible absolute pressure is below 10 mm.

The problems of the refinery, and the conditions of operation are so widely different from the steam power plant, that the power condenser is not suitable for this work. So few manufacturers of this equipment have actual oil refinery experience that it behooves the designer, the operator and the purchaser to think for themselves when it comes to equipment of this type. The cheapest is seldom the most desirable.

Asknowledgment: Thanks are due for the constructive criticism of Dr. Corey of M. W. Kellogg Co., and Mr. Throckmorton of Alco Products, Inc.; for the assistance of Mr. Forncrook of the Elliot Co.; and for the valuable work of Mr. Hunt of Alco Products, Inc., in illustrating this article.

Bureau of Mines Publishes Description and Detailed Drawings of New Recording Subsurface-Pressure Gauge

Recognizing the need for accurate measurements of pressures and temperatures within the reservoir and well "flow strings" in order to apply scientific methods to the solution or analysis of many problems encountered in the production of oil and gas, the United States Bureau of Mines, Department of the Interior, has issued a report describing the design, construction, and operation of a new subsurface-pressure gauge. This instrument has been developed by W. B. Berwald, H. A. Buss, and C. E. Reistle, Jr., at the Petroleum Experiment Station of the Bureau, Bartlesville, Okla., and has been used successfully by Bureau engineers for the past year.

Accurate measurement of subsurface data in producing oil and gas wells is one of the most important steps ever taken to place the practice of petroleum production on an exact scientific basis, for without such knowledge the movement of fluids within the reservoir system from the pore spaces within the rock formations to the wellhead only can be approximated roughly. It is believed that the accurately dimensioned drawings and complete description of the working parts, assembly, and operation of this instrument will be a substantial aid in the future construction of devices for obtaining subsurface measurements in producing oil and gas wells.

Although many engineers have long appreciated the value of accurate subsurface measurements, and many of the larger producing companies now have well-designed, accurate measuring instruments and trained personnel for obtaining subsurface data, making it possible to gather complete records of underground pressures and temperatures in many major fields, it is only within the past few years that the value of these data has been recognized generally.

No attempt is made in the present report to trace the general history and development of measurement of subsurface data nor the application of these data for which many engineers throughout the industry have been responsible for the advancements and improvements that have been made.

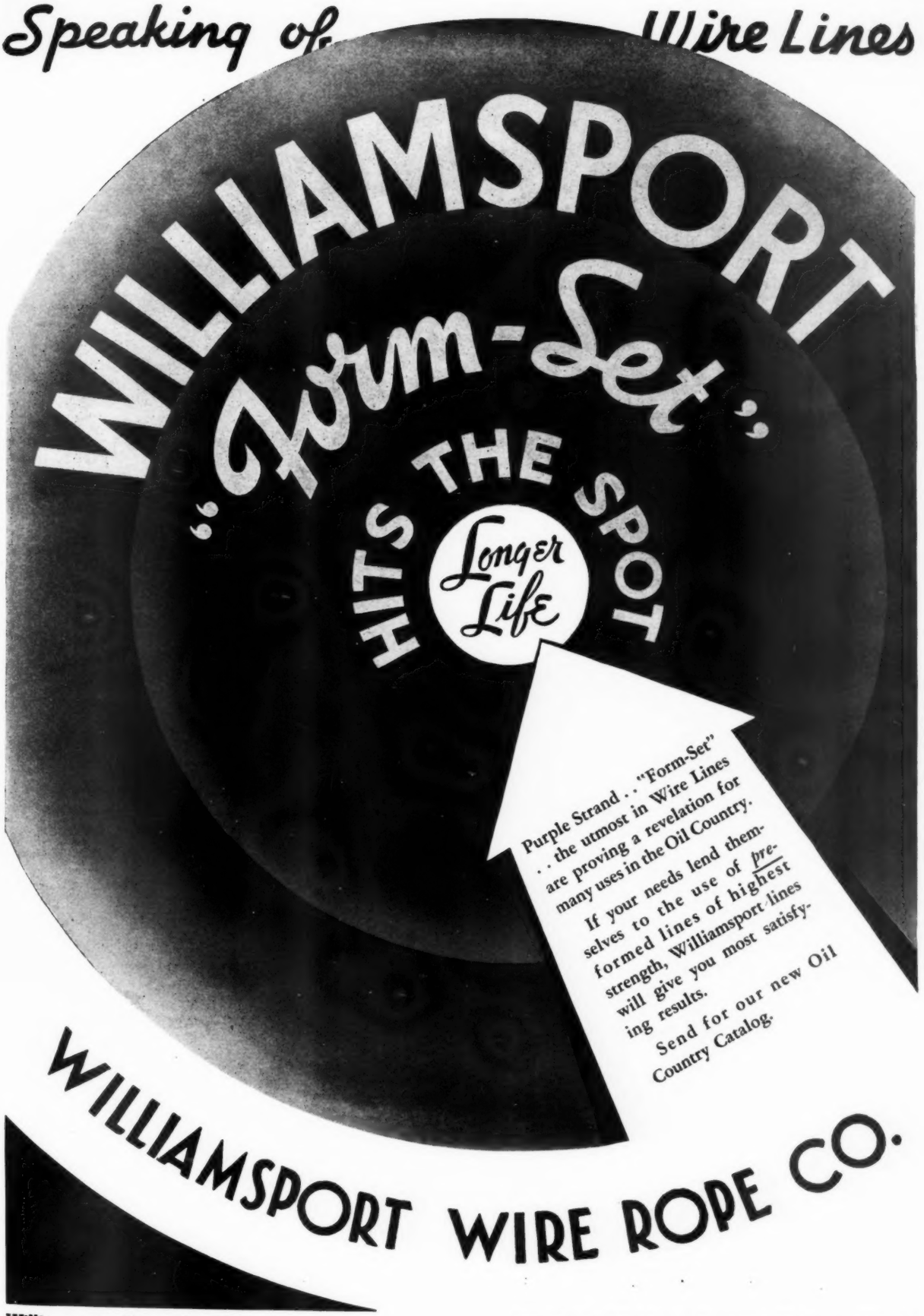
After briefly outlining the evolution of subsurface recording instruments developed by the Bureau of Mines from the initial work of K. B. Nowels at the Bureau's Laramie, Wyoming, field office in 1928, the authors state that they found separate instruments for pressure and temperature eliminate many of the difficulties in construction and operation of a combined pressure- and temperature-recording gauge such as was previously developed and used by Bureau engineers. Accordingly the design of the new instrument, which has an outside diameter of 1¾ in. and an overall length of 57⅞ in., has been limited to pressure measurements, with the idea that a separate instrument can be used in conjunction with it when temperature measurements are desired.

The pressure element in the new gauge is designed on a pressure-measuring principle entirely different from that used in the combination gauge of earlier design. In place of a close-fitting plunger working against a steel spring the new instrument depends on the movement of a series of thin, tempered-steel diaphragms. Pairs of these diaphragms are connected in tandem in such a way that a series acts like a steel bellows, the total movement of the bellows or pressure element being the cumulative movement of the individual diaphragms in the series. The pressure element is filled with oil held under a slight pressure by means of a thin bronze bellows, which also forms the contact surface between the fluids in the well and the oil in the pressure element in the same way that this type of bellows was used in the combination gauge. Subsurface pressures are transmitted through the bronze bellows to the oil inside the pressure element which causes cumulative movement of the thin diaphragms. This motion is multiplied and recorded on a chart; the recording mechanism is identical with that used for the older combination gauge.

Several important advantages over the older combination gauge have been gained in the new gauge through the pressure-measuring principle employed. The pressure element is a closed system, and during the time the instrument has been in use no leakage of oil from this element has occurred. It has no moving pistons or parts subject to change in dimensions due to wear, and the calibration of the gauge has not changed appreciably through use. The diaphragms necessarily flex back and forth, and possibly after considerable time and use may be subject to some metal fatigue. However, the necessary movement of single diaphragms can be controlled to such an extent by selecting proper thickness of metal and numbers of diaphragms in series that excessive metal fatigue is unlikely. Having no compression springs, the mechanism of the new gauge is simpler and more compact and as there is less lost motion in the pressure element, consistent and more nearly identical calibration curves are obtained with increasing and decreasing pressures.

The construction details of the instrument are given for convenience under the four major parts, namely, pressure element, multiplying mechanism, recording mechanism, and inside and outside covers and end pieces. Instruments under development by the Bureau at the present time are a recording pressure gauge, built on the same principle as the one described in the present report, but designed for higher pressures and a new temperature-recording gauge, which employs the same principle as the pressure gauges but is actuated by the vapor pressure of a highly volatile liquid confined in the temperature element.

Report of Investigations 3291, Bureau of Mines Multiple-Diaphragm Recording Subsurface-Pressure Gauge, may be obtained without cost upon application to the Information Division, U. S. Bureau of Mines, Washington.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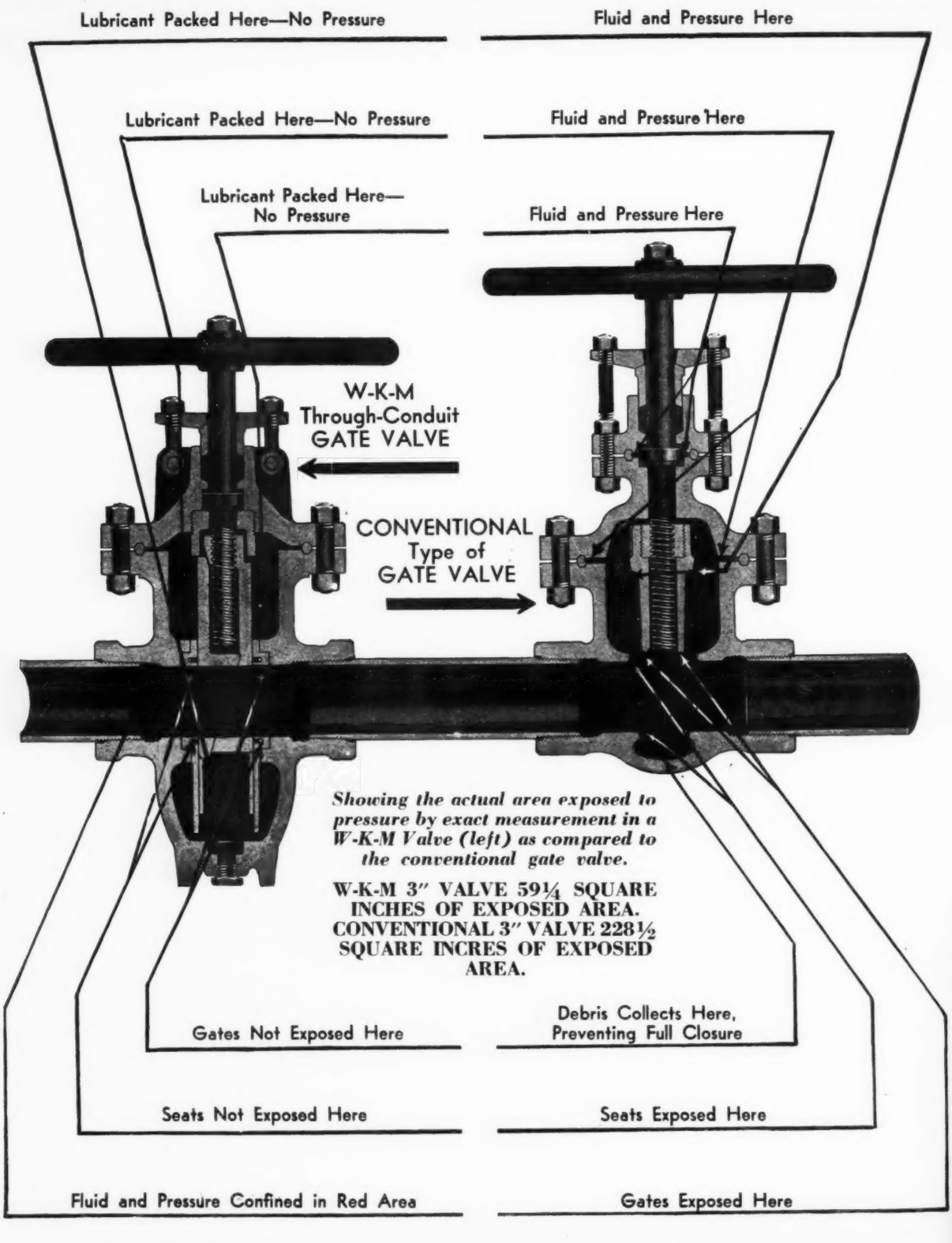
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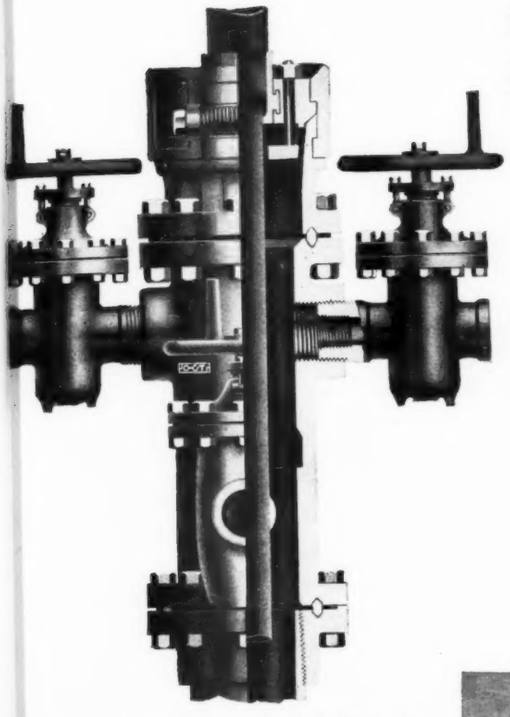
CONVENTIONAL Type of GATE VALVE
Gates Not Exposed Here
Debris Collects Here, Preventing Full Closure
Seats Not Exposed Here
Seats Exposed Here
Fluid and Pressure Confined in Red Area
Gates Exposed Here

Showing the actual area exposed to pressure by exact measurement in a W-K-M Valve (left) as compared to the conventional gate valve.

W-K-M 3″ VALVE 59¼ SQUARE INCHES OF EXPOSED AREA. CONVENTIONAL 3″ VALVE 228½ SQUARE INCRES OF EXPOSED AREA.

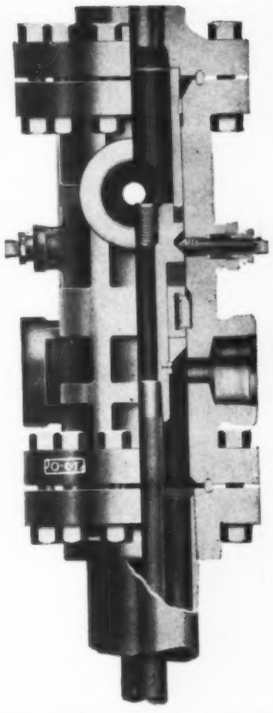
O·C·T Christmas-Trees

HAVE SET THE STANDARD FOR PRODUCING HOOK-UPS!



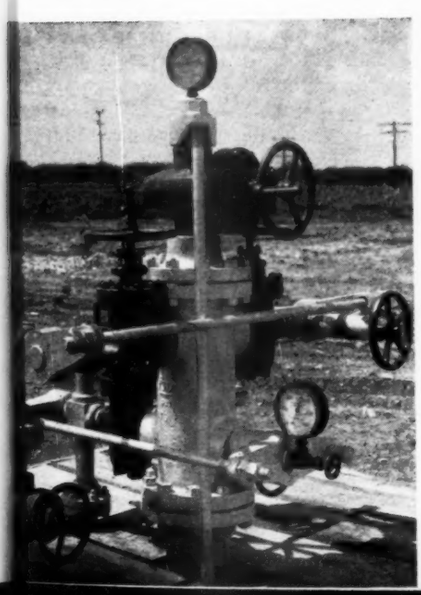
It's the only complete Christmas-tree allowing installation before plug is drilled. You flange the entire 'tree on your oil string after cementing . . . no rotating to connect up. You drill in and run and land tubing right through the Christmas-tree.

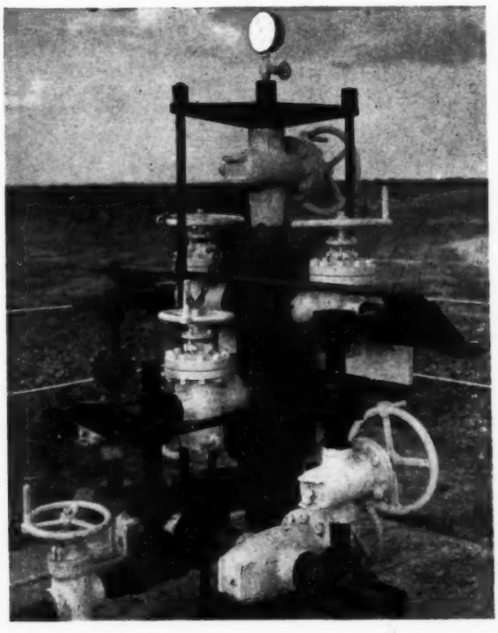
It's 75% stronger, considerably lighter, requires less space, and has fewer parts. Male thread valves screw directly into tubing head, eliminating nipples. Flow area is full opening, allowing swabbing 2½" tubing through a 2½" valve.

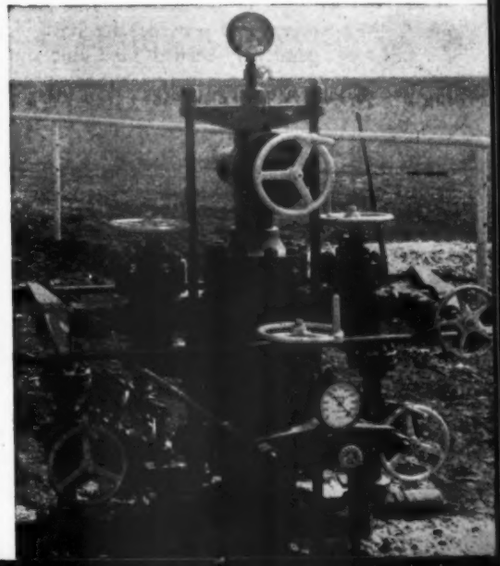


Showing the method of drilling in through complete X-tree, and running and landing tubing through O-C-T Type "H" blowout preventer. This eliminates the hazard of installing the 'tree after plug has been drilled.

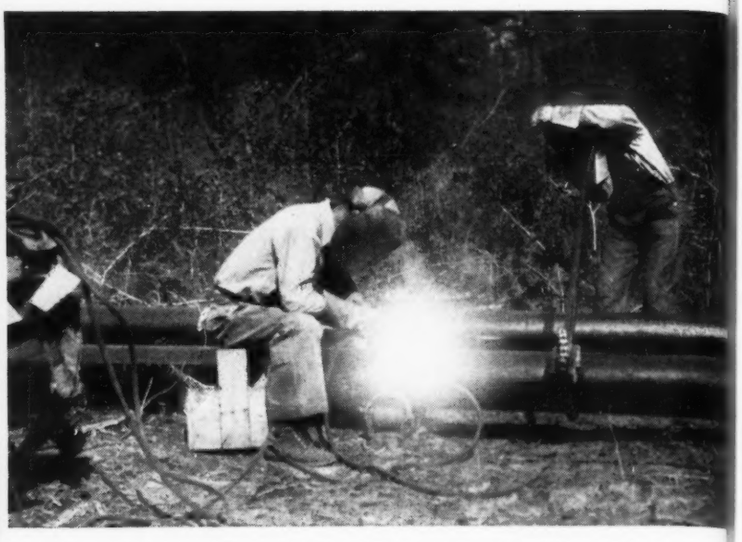
Cutaway section of main body of X-tree, with tubing hanger in place. The I.D. of this main body is the same as the I.D. of the casing it is made to fit.







These three field views are examples of the hundreds of O-C-T streamline 'trees now affording *safe, permanent* hook-ups for operators throughout the Southwest.



Above—Firing line welder making a roll weld. Left—Making a sag. Note the dense woods; a large portion of the line was laid through country heavily covered with timber.

By

FRANK H. LOVE

Construction Features of American Liberty Pipe Line to Gulf Coast

COMPLETION this month of 107 miles of 8-in. line and the erection of four pumping stations between Rusk and Conroe, Texas, by the American Liberty Pipe Line Company will provide the East Texas field with its first independently-owned pipe line outlet to the Gulf Coast. The American Liberty, already the owner of a line between Conroe and Houston, and one from the East Texas field to Rusk, the latter purchased recently from the Liberty Pipe Line Company, is connecting these two systems, the whole comprising a continuous carrier to the coast. The additional pumping facilities necessitated have been provided by the construction of stations at Oakhurst, Pennington, Rusk, and Summerfield. With one exception the pumping equipment is Diesel powered. In this one instance electric motors are employed. Pumps are entirely of the centrifugal type.

Unfavorable weather conditions retarded construction activities considerably the early part of the year, delaying the line's completion approximately one month from the time originally planned. Some of the heaviest snows experienced by Texas in many years came during this period, and, in addition, there were numerous rains with which to contend.

The line is laid through rugged country for the most part, sections heavily covered with timber, and while little rocky soil has been encountered, many portions traverse boggy land.

Except for these low, boggy areas where the pipe had to be hauled in by tractors, stringing was accomplished with little difficulty. Hand-ditching was resorted to in some of the swampy areas, although, for the most part, the two ditching machines cut a trench 36 in. in width and 22 in. in depth with little difficulty. The ditching equipment made excellent progress, on the most favorable days averaging as much as 11,000 ft. each per day, although 7000 ft. was considered an average day's work.

In the course of the line's construction it has been necessary to cross two rivers, the Neches and the Trinity, the former, the narrower of the two streams, being approximately 80 ft. wide from bank to bank, the Trinity 300 ft. across. In both instances dynamite was used to shoot away the shoulders on either bank. In the case of the Neches the pipe was laid on the bottom of the river, while in crossing the Trinity a trench was blasted, into which the line was placed. The river strings were made up on shore, coated with hot enamel, a bull plug placed over one end, and the pipe pulled into place by a winch line operated off a truck.

Numerous creeks, sloughs, railroads, and highways also have been crossed. All pipe laid beneath creek bottoms or sloughs is first primed and coated by hand with hot enamel, these spots and the river crossings being the only portions of the line given such protection. Highways and railroads are bored with conventional boring equipment, the line pipe placed in a 10-in. casing, and the ends sealed with concrete. On all such crossings 2-in. vents are installed.

The line is being tested in 35-mile sections, being given a cold water test of approximately 800 lb. pressure. In addi-

Announcing

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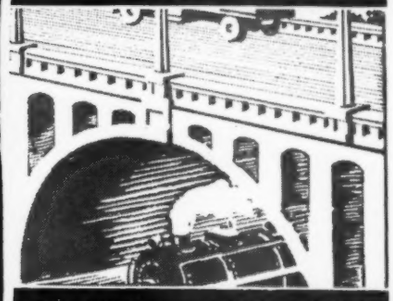
HIGH EARLY STRENGTH

PORTLAND CEMENT

FOR OIL WELL CEMENTING AND OIL FIELD CONSTRUCTION

BUILDINGS READY FOR OCCUPANCY WEEKS SOONER

SPEEDS HIGHWAY WORK AND SAVES COSTLY DETOURS



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FOR USE IN ALL CONCRETE CONSTRUCTION WHERE SAVING OF TIME IS A VITAL FACTOR!

TRINITY PORTLAND CEMENT COMPANY'S technical staff, after thorough research and experimental work, have perfected and produced a "HIGH EARLY STRENGTH" Portland Cement. Today it is ready for you.

Trinity "High Early Strength" Is a TRUE Portland Cement

Trinity "HIGH EARLY STRENGTH" Portland Cement possesses all of the desired characteristics of Standard Portland Cement — plus the ability to produce concrete of higher strength at one and three days.

Trinity "HIGH EARLY STRENGTH" Portland Cement meets and exceeds the Tentative Standard Specifications for High Early Strength Portland Cement of the American Society for Testing Materials, Designation C 74-30 T.

Will Speed Up Every Type of Concrete Construction

Trinity "HIGH EARLY STRENGTH" Portland Cement will speed up every type of concrete construction—Buildings and Building Additions . . . Street Paving . . . Bridges and Grade Separations . . . Oil Well Cementing.

It Is Backed by Thirty Years' Experience

Trinity "HIGH EARLY STRENGTH" Portland Cement is manufactured by the organization which produces Trinity Standard Portland Cement — favorably known and used throughout the Southwest for the past thirty years.

Communicate with our nearest office for advice and assistance in connection with your concrete problems.

TRINITY PORTLAND CEMENT COMPANY

DALLAS • FORT WORTH • HOUSTON

tion, welds have been tested throughout the construction of the line. Wherever the inspectors deem it advisable spools are torch-cut from the line, and from this a coupon containing a portion of the weld is cut, placed in a hydraulic machine, and given the pull test. If the pipe breaks before the weld the latter is passed by the inspectors.

In keeping with good pipe line practice two grades of pipe are being used, a heavy pipe, weighing 24.69 lb. per ft., for a distance of approximately 18 miles on the discharge side of each pumping station where the pressures are the greatest, and a lighter pipe, weighing 19.48 lb. per ft., on the remainder of the line.

The Fredell Construction Company of Houston, Texas, and Denver, Colorado, is the general contractor.

PUMPING STATIONS

The National Supply Construction Company, subsidiary of the National Supply Company, was the contractor for the construction of the pumping stations. At Oakhurst, Pennington, and Rusk the pumps are Diesel powered. Each station is equipped with two 260-hp. 6-cylinder, 9 by 12, Diesels having a rated speed of 600 revolutions per minute. The prime movers are connected through gear increasers to centrifugal pumps, the gear ratio being 6 to 1. The pumps have a capacity of 24,000 bbl. per day operating at 375 lb. pressure. They are arranged to operate singly or in series, and when operating in the latter manner maximum capacity is attained. When used singly either unit will pump approximately 18,000 bbl. per day.

The Diesels are of the four-cycle, cold-starting, rail-injection type. The engines are entirely enclosed, are dust-proof and oil-tight, yet so designed that virtually all parts are readily accessible. Heat exchangers, with the incoming stream of crude utilized as the cooling medium, serve to cool the jacket water. The engines are equipped with intake air filters, and Maxim silencers have been placed on the exhausts. Automatic shut-downs prevent operation of the engines in event proper circulation of the jacket water or the lube oil fail, or the temperature of either exceeds a predetermined point.

Fuel oil is taken directly from the line and pumped to an elevated main fuel tank holding approximately a week's supply. Most of the sand and scale settles out in this tank, but as a final precaution the fuel is centrifuged before going to the day tank situated well below the floor of the engine room. Here it is picked up by the fuel service pump on the engine. In centrifuging certain oils, East Texas crude especially, there is a tendency during cold weather for some of the paraffin to separate in the centrifuge. To overcome this condition heat exchangers have been placed in a manner to heat the fuel oil before it reaches the centrifuge. Jacket water passing concurrently to the fuel stream is the heating medium.

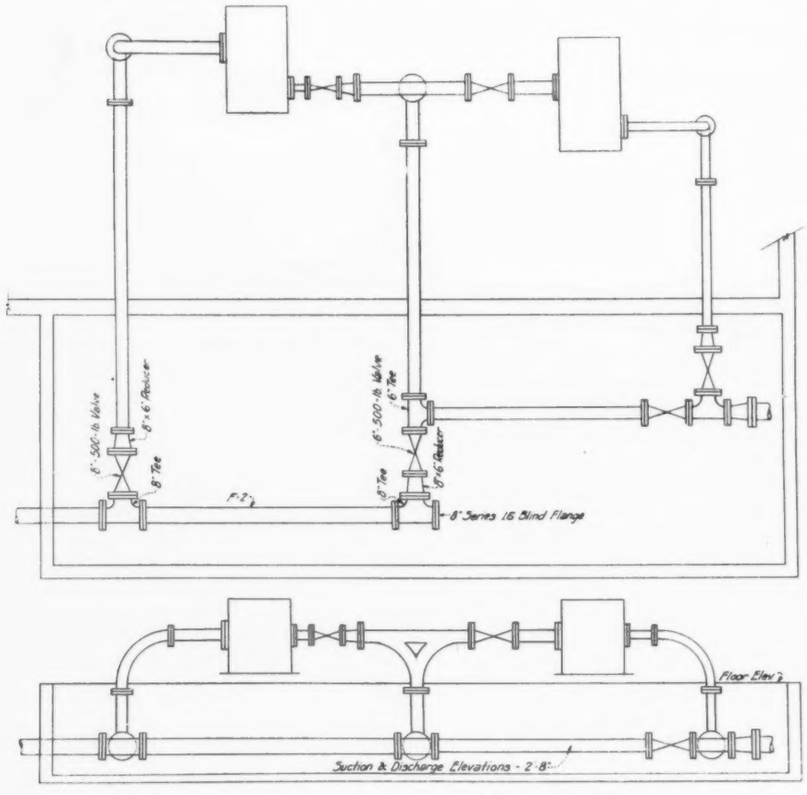
The lubricating system is of the pressure feed type. A built-in pump operated off the crankshaft delivers the lube oil to the various parts of the engine. The oil is filtered on each passage through the engine and is cooled by circulation through a water-to-lube heat exchanger, the latter being situated below the floor line.

A single-stage air compressor driven by a gasoline engine provides the 80-lb. minimum starting air required for the prime movers.

The station at Summerfield is of a somewhat different type from those just described. Its equipment consists of two 250-hp., 2-pole motors, having a rated speed of 3550 r.p.m., direct connected to centrifugal pumps each of which has a capacity of 31,000 bbl. per day at 375 lb. discharge pressure. The units are arranged for operation either singly or in series. At this station no auxiliaries are needed; power for light is obtained by using a transformer to step down the voltage from the high line. At Summerfield two 55,000-bbl. working tanks have been provided, this equipment being installed at none of the other stations. The crude will be pumped straight through from Summerfield to the Gulf Coast, although at Pennington, Rusk, and Oakhurst 5000-bbl. surge tanks have been provided as an emergency measure; further, in event it should become necessary to shut down any one station, the design is such that the station can be by-passed without interrupting the flow of oil through the system.

Each of the Diesel-powered stations has an extremely neat and compact generating plant consisting of a 5-kw. generator driven by a 14-hp. gasoline engine.

Engines, pumps, and most of the auxiliary equipment are housed in one main station building, a steel frame structure with galvanized covering. The building is 36 ft. by 42 ft., with 12-ft. side walls, and in one corner is built the office. All piping is below floor in trenches, covered with tread plates, and light wires are in conduits suspended from the roof trusses. Lighting fixtures are entirely vapor-proof. Another feature of the station building proper is that it is equipped with monorails over the center line of each engine, operating parallel with the crankshaft, for use in dismantling and reassembling equipment. Adjoining the building is a concrete manifold pit, 31 ft. 9 in. by 11 ft. 3 inches. At the Pennington and Oakhurst stations a small electrically-driven sump pump serves to dewater the manifold pit, while at Summerfield and Rusk the pits have gravity drainage.



Arrangement of piping in manifold pit.

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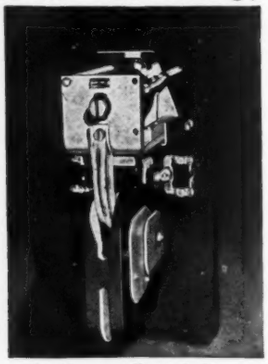
Geo. S. Mepham Corp.

HOUSTON, TEXAS — EAST ST. LOUIS, ILL.

LARGEST MFRS. & IMPORTERS OF MINERAL PIGMENTS IN THE WORLD

Mill-Type D.C. Contactors

A NEW line of mill-type d.c. contactors, intended for severe service, has been introduced by the General Electric Company, Schenectady, New York. Designated as CR2800 contactors, they are equipped with "rocker" bearings, which



are practically unaffected by wear, instead of with pin-type bearings requiring relatively frequent replacement.

The new contactors are constructed of heavy cold-rolled steel and are designed to facilitate inspection of parts. All frames are drilled for mounting mechanical and electrical interlocks so that these devices can be added, if desired, after installation.

Special Lengths of Alligator Steel Belt Lacing

CURRENT literature of the Flexible Steel Lacing Company, 4607-31 Lexington Street, Chicago, Illinois, carries the announcement of special lengths of Alligator Steel Belt Lacing. The nine larger sizes from numbers 15 to 75 are listed in lengths from 14 in. to 96 inch. The lacing is packed carefully, complete with hinge pins and handle gauge pin. The familar sectional rocker hinge pin is supplied for power transmission installations, but a one piece corrugated hinge pin is used on conveyor belts.

As in the standard boxes of Alligator Steel Belt Lacing, the special lengths also are available in "Monel Metal" and non-sparking and non-magnetic alloys.

Dayton Daycoil Oil-Proof V-Belt

A NEW belting, said to be impervious to excessive oil, is announced by the Dayton Rubber Manufacturing Company, Dayton, Ohio. It is called the Dayton Daycoil Oil-Proof V-Belt. The secret of its oil-proof properties is contained in the fact that its base is a synthetic rubber called DuPrene, although DuPrene is only one of several synthetic materials used in its construction, the manufacturers state.

Before announcing the new belt to the trade, the manufacturers put it to test under conditions much more severe than would ever be encountered. The belts actually were run dripping with oil, under full rated load and with reverse idlers and other attachments to stress the strain and intensify the wear. They showed no signs of swelling, stretching or wearing after hundreds of hours of this intensified testing, the manufacturers say. Following the laboratory and dynamometer tests, many field tests were made on machine tool installations where a wide range of oily conditions would be encountered in normal daily plant operations.

Remote Valve Control

TO supplement automatic control systems, The Foxboro Company, Foxboro, Massachusetts, has developed the new "Remote Hand Control." In many processes, automatic controllers stabilize the operation to such an extent that many non-critical flows may be governed by hand valves, which need be readjusted

very infrequently. However, if these hand valves are not easily accessible, it is only natural that even the few necessary adjustments will be neglected. Where these conditions exist, a Foxboro Remote Hand Control mounted on a centrally-located panel enables the operator to adjust manually the degree of opening of an out-of-the-way, inaccessible valve without moving from his station. With it, he can reset a valve several hundred feet away to control temperature, pressure, flow or liquid level using readings from his recording instruments to guide him in making the correct adjustments.

A feature of this remote hand control is the extreme precision of valve setting. It is easy to make a change in pressure on the diaphragm motor of the controlled valve as small as ¼ in. of water or less, the manufacturers state. This means that the valve opening can be altered by as little as a few thousandths of an inch to produce the exact desired flow of controlled medium. Used in conjunction with a Stabilflo valve, the controlled flow can be changed by less than one percent, it is stated. Due to its unique design, there is no pumping or vibrating; air pressure on the diaphragm is held exactly at the desired setting, it is pointed out.

Simplicity and ruggedness mark both the design and construction of the Foxboro Remote Valve Control. It is finished in lacquered cast bronze trimmed with buff nickel.

Barge Loading Oil Hose

INCREASED transportation of oil products by barge has created a demand for a loading hose that is lighter in weight and more easily handled than the heavy combination suction and discharge hose designed for loading and dis-

charging oil products from ocean-going tankers. After a careful study of hose requirements for this service, engineers of The B. F. Goodrich Company, Akron, Ohio, have developed a hose construction that is considerably lighter in weight than the combination suction and discharge hose, yet sturdy enough to stand rough handling, the manufacturers state.

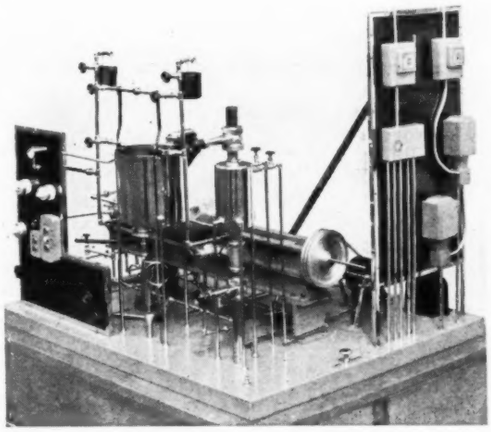
This new hose is offered in either smooth or rough bore construction. However, since barge loading is primarily a straight discharge service, the smooth bore type offers a distinct advantage in that its construction permits approximately a 12 percent to 15 percent faster delivery.

Major construction features of the smooth bore (Type 800) hose are oil-resisting tube, reinforcement of round steel wire, and a tough rubber cover. The rough bore (Type 850) hose is the same in every respect except that it has an internal coil of flat steel wire for added reinforcement.

Both types of barge loading hose are available in 4-in. and 6-in. sizes. For the 4-in. size, a flanged brass fitting has been designed that is attached to the hose with expansion rings. The 6-in. hose is coupled with standard steel nipples and flanges.

Baroid Sales Company Showing Filter Press and Service Car at Houston Exposition

BAROID Sales Company, Los Angeles, Houston, and Tulsa, is showing at the Oil Equipment and Engineering Exposition, Houston, Texas, a model of the filter press or mud performance tester built recently in the company's Los Angeles laboratories. This filter press duplicates, as nearly as possible, bottom hole conditions with regard to temperature and pressure and determines the results of the actions thereof on drilling muds.



The company also is exhibiting a model of a field service car. These cars are completely equipped to enable Baroid service engineers to make all necessary tests right at the well. The cars carry both Stormer and Funnel Viscosimeters; a Mudwate Hydrometer; screens for determining sand content; a centrifuge and Wulff pH outfit for determining the acidity or alkalinity of the mud; an electric hot plate and evaporation dish for determining the percentage of solids, and all other necessary equipment for complete testing of mud at the well.

Valve Seat Development Announced by Axelson Manufacturing Co.

THE Axelson Manufacturing Company, Los Angeles, after many years' experience in the manufacture of seats and balls for oilwell pumps, has announced a new development: a seat with a contour surface conforming in part to the contour of the ball.

"Originally valve seats were designed with a straight bevel on the seating area," explains R. M. Humphreys, assistant director of sales for the Axelson Manufacturing Company. "No attempt was made to fit the seating to the ball. Next, a concave surface lapped to the ball was developed, giving a good fluid seal but leaving a sharp edge that was easily turned over if the ball seated improperly. To overcome this, Axelson developed the Convex Seat that presented a line contact to the ball, eliminating the sharp edge. This served for many years but still left something to be desired. Axelson's latest design has a seat contour that combines the advantages of both previous types. This contour starts at the top of the seat as a convex curve merging into a concave surface conforming to the ball. The result is a concave seat offering a good seal, yet has no sharp edges. This contour is giving excellent service in all fields.

"The materials in Axelson seats are carefully selected for desired qualities; their physical properties are held to close limits. The seats are blanked and formed complete from solid bars. After inspection they are sent to the heat-treating department to be hardened in electric furnaces. These furnaces have automatic controls that hold the temperature to close limits. This is of utmost importance in heat-treating alloy steels as a few degrees variation in furnace temperatures makes a decided difference in hardness and corrosion-resisting qualities. To check heat-treatment, the hardened seats are carefully checked in the inspection department. This close control enables us to duplicate exactly the qualities that have proven best in service. Following inspection, the seats are finished ground to a high degree of accuracy. The last mechanical operation is lapping. This is done in a machine of our own design that automatically laps both sides of each seat to a perfect seal with its mating ball. All seats are vacuum tested to be sure of this seal and are then packed in sealed containers."

As a pioneer of seats and balls for oil wells Axelson offers four well known lines, it is stated. They are known as the Axelson Axloy, Axelson X-L, Axelson Durax, and Axelson Acme. These four seats and balls are made in various pump sizes and are said to cover all working conditions. They conform to A.P.I. specifications.

Brown Portable Thermometer

THE accompanying illustration shows the improvement that has been made in the portable type of recording thermometer; the sensitive element (bulb) has been placed where it will respond quickly and accurately to changes in the surrounding temperature.

Mounted out in the clear, the mercury-filled bulb is subjected to the natural air currents and, therefore, records true temperatures, the manufacturers state. The new design also is said to result in greater sensitivity since the measuring system is in no way affected by the temperature of the instrument case.

In addition to these improvements, the Brown Self-Contained Portable Thermometer is built to withstand the rough handling that must be expected under conditions where portable instruments are used. The metal handle and metal legs are practical and sturdy. The black-enameled, die-cast aluminum case is light in weight and corrosion-resistant. The completely gasketed door is moisture-proof and the door-in-handle lock is tamper-proof.

Brown Portable Thermometers are used wherever correct atmospheric temperatures are essential for comfort or manufacturing to promote efficiency and improved products. The permanent, easily read temperature record that is produced on a large 8-in. 24-hr. chart, eliminates all guess-work.

For additional information, write The Brown Instrument Company, Wayne Junction, Philadelphia, Pennsylvania.

Vernon Tool Co. Exhibiting Mud Screen and Tool Joints at Houston Show

VERNON Tool Company, Ltd., Los Angeles, California, is showing at the Oil Equipment and Engineering Exposition, Houston, Texas, the McNeely Vibrating Mud Screen and a complete line of tool joints.

Features of the McNeely Mud Screen include a non-whipping screen cloth that

Vernon Tool Joints

is said to have extra-long life; curved screen surface that assures rapid removal of waste cuttings; an equally transmitted vibrating force to all parts of the screen that eliminates dead spots, and a compact, sturdy, all-steel type of construction that saves ground space and head room, and makes installation and removal easy. This Vernon display is in operation.

Vernon tool joints embody such advantages as: absolutely true threads because threads are cut after the joints are

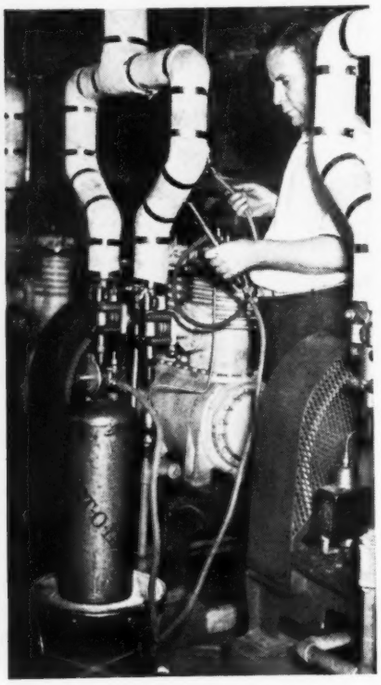
McNeely Vibrating Mud Screen

hardened; elimination of warping out-of-round, and highest-quality steel heat-treated to very narrow limits.

Other Vernon products include pumping adjusters, drill collars, kellys, subs, fish-tail bits, rig irons, tubing heads, pitmans and christmas trees.

Halide Leak Detector for Refrigerant Gases

DURING recent years there has been a continued growth in the use of non-combustible halide gases as refrigerants. The fact that these gases are relatively odorless, tasteless, and colorless renders it necessary to have a quick and sure method of locating leaks while cooling units are being installed and later during servicing. Such a device, known as the Prest-O-Lite Halide Leak Detector, has been developed by The Linde Air Products Company, 30 East 42nd Street, New York City.



It should be pointed out that certain halide derivative gases used as refrigerants, such as ethyl chloride and methyl chloride, are combustible. Insurance companies and safety rules prohibit testing for leaks of a combustible gas with any flame. Therefore, under no circumstances, should any flame leak detector be employed for locating leaks of any combustible gas. Before using any device, the nature and property of the halide gas used should be ascertained if not definitely known.

The Halide Leak Detector consists of a regular Prest-O-Lite needle valve torch handle assembly, a burner that includes a suction nipple for attaching a rubber hose, and a chimney with a copper reaction plate. The rapid flow of acetylene through the burner causes a suction that draws in any refrigerant gas near the open end of the suction tube.

To operate the detector, the flame is first adjusted so that the top of the outside cone is level with or slighly above the chimney of the detector. The open end of the suction tube is used to explore around those places where a leak might occur. Any halide refrigerant gas drawn into the burner is decomposed with the formation of free acids. These acids, coming into contact with the hot copper reaction plate cause instant color response in the flame. Visible color indication of the smallest concentration of refrigerant gas by a green-tinted flame is given by the Prest-O-Lite Halide Leak Detector. When a large amount is present, the flame assumes an intense violet color. After the source of the leak has been passed, the flame clears almost instantly.

Portable Well-Servicing Winch Has Arc-Welded Telescoping Boom

A NEW portable motor-driven oil well servicing winch, that is said to make any truck a fast, powerful unit for pulling and running rods and tubing, bailing, swabbing, and drilling, has been announced by the Franks Manufacturing Company, Tulsa, Oklahoma.

This unit can be installed at little cost on any truck, the manufacturers state. The winch is securely attached to the truck frame directly behind the cab. Power is taken from the truck motor through a power take-off mounted on the truck propeller shaft, thus giving flexibility of speed changes afforded by the truck transmission. Pulling power of the winch is governed by the power of the truck motor.

A feature of this unit is a horizontal telescoping boom that telescopes directly out the back of the truck. This boom is entirely arc-welded with shielded equipment manufactured by the Lincoln Electric Company, Cleveland, Ohio. This boom at the block end can be telescoped far enough away from the drum to assure correct spooling of cable. Another advantage is that the boom, once the job is finished, is placed in road position and does not interfere in any way with the truck bed or draw bar.

Operation of the equipment is unusually simple and direct, it is said. Getting ready with the unit requires no rigging up. Upon reaching the location, the end of the boom at the block may be anchored to framer sill, derrick corner or any place strong enough to stand the load. If the pulling mast is used the end of the boom is anchored to the base of the mast. Complete alignment of block and winch drum is constantly maintained, regardless of anchor point or tilt of truck.

The winch framework possesses the great strength and rigidity of one integral piece of steel, it is pointed out. The frame is of built-up type and consists of heavy steel channels and angles, electrically welded together.

Arc-welding also is used in construction of the winch drum. This drum consists of a 12¾-in. reinforced barrel 34½ in. in length with 36-in. steel flanges at each end electrically welded with double brake flanges 7 in. wide.

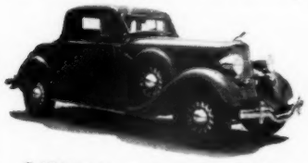
The drum capacities with different size cable are as follows: 10,000 ft. of ½-in., 7900 ft. of 9/16-in., 6500 ft. of ⅝-in., 4400 ft. of ¾-in., 3250 ft. of ⅞-in., and 2500 ft. of 1-inch.

TODAY—MUD IS A *Different* PROBLEM

OLD-TIMERS of the oil fields still talk about the days when heroic, hard-boiled teamsters with cracking whips cussed stubborn mules and heavy loads through slimy, sticky, hub-deep mud.

Today—mud is a different problem! When properly conditioned, it plays a leading part in safer, faster, more economical drilling. The deeper the well, the more essential that properly controlled mud be used.

BAROID—weighted drilling muds, when properly used, control oil, gas and water pressures and hold in place formations which tend to cave or slough into the hole.



BAROID Service Engineers with specially-equipped cars make mud tests right at your well. Our up-to-date laboratories at Los Angeles, Houston and Tulsa provide drilling mud research of inestimable value to the Oil Industry.

AQUAGEL—conditioned drilling muds, properly used, help prevent caving, loss of circulation, stuck drill pipe and casing; help to reduce abrasion, suspend drilling mud solids and seal off fissures, caves and minor flows of gas and water.

STABILITE reduces the viscosities of thick drilling muds and increases their wall-building properties. STABILITE muds quickly release gas from gas-cut muds.

BAROCO clay makes 40 barrels of excellent 15 centipoise viscosity drilling mud per ton, builds a better wall than ordinary clays, and resists the "flocculating" action of salt and salt waters.

BAROID Products and Service will greatly assist you in the solution of your drilling mud problems. Be sure to use them—for best results!

BAROID PRODUCTS

HOUSTON APR. 20-23 SEE OUR EXHIBIT OIL EQUIPMENT & ENGINEERING EXPOSITION

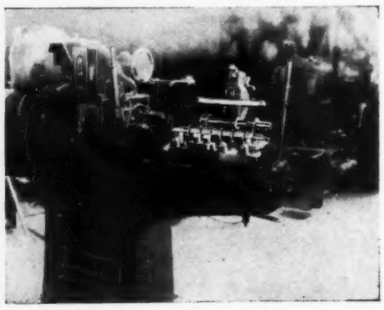
BAROID SALES COMPANY

LOS ANGELES • TULSA • HOUSTON

NATIONAL PIGMENTS & CHEMICAL COMPANY, ST. LOUIS

Special Work-Holding Fixture

A WORK-HOLDING fixture designed to maintain concentricity between both ends of a threaded part has been placed on the market by the Landis Machine Company of Waynesboro, Pennsylvania, for use on its threading machines. The accompanying photograph shows this fixture applied to a Landis single-head lead-screw motor-driven threading machine as



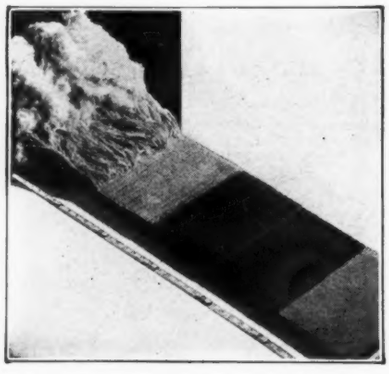
used for threading both ends of a Diesel engine cam shaft. A ⅞-in hardened and ground Lanco head is used for cutting the threads. In this case especially close tolerances were placed on the concentricity of the two ends. To insure this concentricity the cam shaft is held in V grips made of hardened steel and gripped on the bearing surfaces at each end of the cam shaft and is clamped in position by a special self-aligning clamp that is shown in the open position.

The fixture is attached to the carriage of the machine and can be adjusted to obtain the required alignments. The rear locating plate can be adjusted for different lengths of cam shafts.

The design of the fixture is so flexible that it can be adapted very readily for holding other types of work requiring the threading of both ends in true alignment and can be supplied for any size Landis threading machine.

Gatke Deep-Well Woven Brake Lining

AN improved woven brake lining is announced by the Gatke Corporation, Chicago, designed especially for oilwell



drawworks to afford safer handling of excessive loads and eliminate brake flange wear. The highest grade asbestos fibre is used in "Deep-Well Woven," from which every particle of abrasive rock dust is said to have been removed by a special Gatke process. To provide additional protection against scoring, soft zinc alloy wire is combined with the abrasiveless asbestos fibre. Large looms, built especially for the purpose, are used to weave the material into a unified mass with no layers to strip or peel, it is stated.

This tightly woven material is thoroughly saturated with a special high-heat-resisting frictional compound of infusible resins. The combination of asbestos-spinning fibre, zinc-alloy wire, and this special frictional compound is said by the manufacturers to afford tremendous tenacity yet uniform and smooth release under all operating conditions.

Baking, calendering, and hydraulically compressing forms the material into a dense, compact structure that is impervious to oils, water and grease, has long wearing qualities, and sufficient flexibility to conform with various brake flange diameters, it is claimed.

This new type woven brake lining is made in all sizes up to 14 in. wide by 1¼ in. thick and is recommended by the manufacturers for all industrial uses where severe service and high temperatures are encountered.

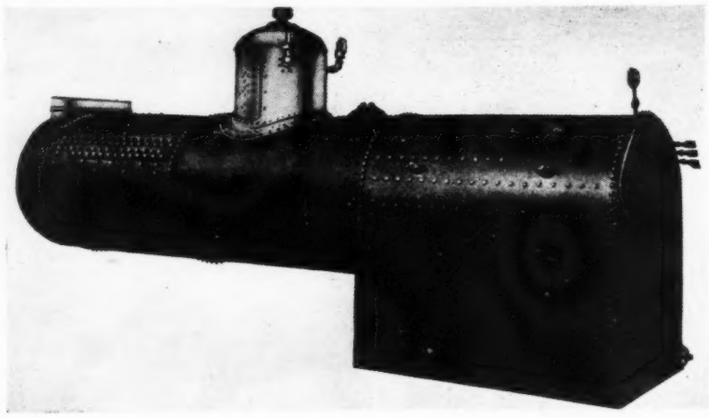
Johns-Manville Improved Heavy Duty Brake Lining

A RECENT advance in the field of heavy duty friction materials is Johns-Manville Style No. 900 woven and compressed brake lining. This product has been introduced after several years of experimentation and development in the J-M laboratory and in the field. It is being offered for general use on all kinds of heavy industrial equipment.

Woven and compressed lining incorporates the fundamental structure of the solid woven lining with the high wearing qualities of the compressed styles. The outstanding feature of woven and compressed lining, as compared with the folded and compressed styles, is that it cannot ply separate in high-temperature service, the manufacturers state. It has the same low rate of wear and efficient friction characteristics as the folded and compressed type, it is said. It also is flexible, readily formed, and is adaptable to various speed requirements. In addition, it is mechanically strong and will withstand severe shock-loading, it is pointed out.

Lucey Rivetless Fire Box Oil Country Boiler

DURING the early part of 1934 the Lucey Boiler and Manufacturing Corporation of Chattanooga, Tennessee, placed upon the market an oil country boiler embodying some marked changes in design for this type boiler. Briefly, those changes consisted in butt welding the fire box heads to the fire box wrapper under U. S. patents granted. By this construction, all of which is approved by the A.S.M.E. Boiler Construction Code, the section of metal between the fire and the water is of uniform thickness throughout, and the heat-transfer is not retarded by lapped plates and rivet heads. Overheating, leaky seams, and burned rivet heads are avoided, it is said.



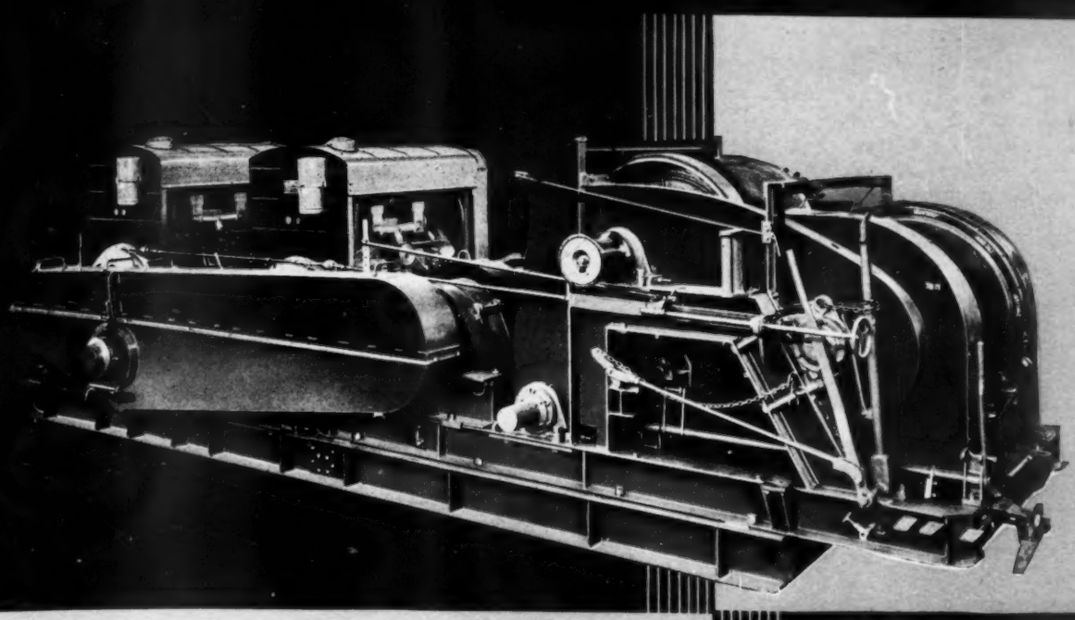
For classification purposes only, the American Petroleum Institute rating of "one horsepower to each ten square feet of heating surface" is used. Nevertheless, it was thought that through basic principles in design; such as, thin heat-transfer sheets, short tubes, and their arrangement, together with the new construction of the fire box, a much better development was to be expected than with the boilers without these features. This at the same rate of firing. To ascertain whether this were true, during August and September of 1935 an actual test of a battery of the new Lucey boilers in operation under field conditions was authorized.

In the tests as conducted on the four Lucey 100-hp. rivetless fire box boilers, each with some 1040 sq. ft. of heating surface, 9330 cu. ft. of gas was burned per hour, per boiler, with a heat-value in thousands of B.t.u.'s of 10,701. The steam produced per hour, per boiler, was 6547 lb., or a ratio of .612 lb. of steam to each 1000 B.t.u.'s burned.

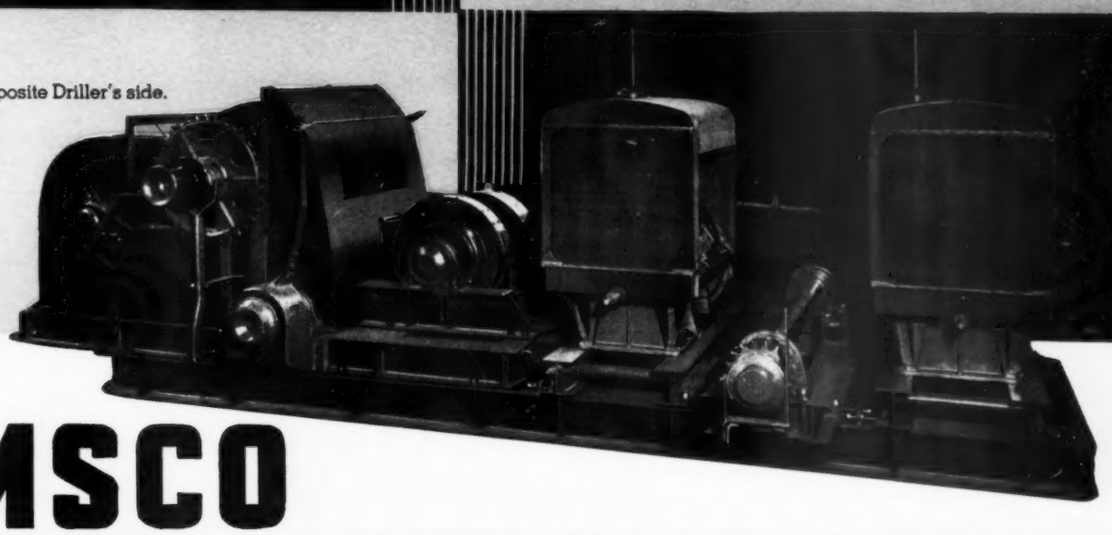
From a test of four 125-hp. boilers, each with 1250 sq. ft. of heating surface, conducted by the A.S.M.E. at Oklahoma City, in 1932, 6469 cu. ft. of gas was burned per hour, per boiler, with a heat-value in thousands B.t.u.'s of 7872. The steam produced, per hour, per boiler, was 4318 lb. per boiler, or a ratio of .548 lb. of steam to each 1000 B.t.u.'s burned.

Comparing these two tests shows that the 100-hp. Lucey, 84-in. rivetless fire box boiler, though having 20 percent less heating surface, nevertheless produced 11.6 percent more steam than did the 125-hp. boiler at the same rate of firing or for each 1000 B.t.u.'s of fuel burned and under similar operating conditions, it is pointed out. The application of this increased capacity percent indicated that the new Lucey boiler is in reality one of 139.5 horsepower.

Bulletin No. 141 and "Report of Tests," substantiating the above facts, are available upon request.



Driller's side.



Opposite Driller's side.

SEE YOU AT THE INTERNATIONAL PETROLEUM EXPOSITION 1936
9TH WORLDS FAIR OF THE OIL INDUSTRY TULSA, U.S.A. MAY 16 TO 23

EMSCO

PORTABLE 46" 4 OR 8-SPEED DRILLING MACHINE

with Dual Motor Drive

For Economical Rotary Drilling

WHEN DRILLING

One motor operates rotary machine through the reverse and friction clutch and the drawworks, and the second motor operates the pumps through a countershaft. When additional power is required for either pumps or drawworks, the drives are so arranged that the power from both motors or each motor may be utilized for driving either the pumps or the drawworks or both simultaneously.

WHEN COMING OUT OF HOLE

Both motors may be used direct to reverse and friction clutch to operate drawworks, thus making possible greater speed and consequent saving of time.

CONTROLS

A single trombone control system, mounted conveniently at driller's standard position, operates both motors and reverse and friction clutch simultaneously. A special connection is provided for operating motors independently.

BRAKE

An Emsco Type CB Multiple Leverage Brake with perfected safety equalizer is standard equipment.

CATHEADS

Two standard catheads and one automatic cathead for breaking joints are provided.

The complete unit, without pumps, can be moved in two sections or, to further facilitate ease in transportation, the drilling machine, the reverse and friction clutch, the two motors, the countershaft or the base may be easily removed and handled separately.

THE CONTINENTAL SUPPLY COMPANY

General Offices: DALLAS, TEXAS

Export Office: CONTINENTAL EMSCO CO., Inc.
30 Rockfeller Plaza New York City, N. Y.

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"SERVING THE OIL AND GAS INDUSTRIES"

CONTINENTAL

Erwin Burns New General Manager Grant Oil Tool Company

ERWIN BURNS

JOHN GRANT

HARRY HESTER

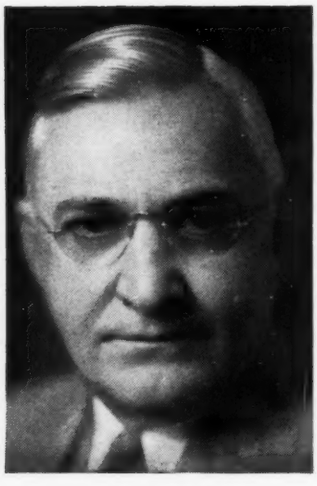
Announcement of the appointment of Erwin Burns to the post of general manager of the Grant Oil Tool Company is made by John Grant. Burns recently left the Baash-Ross Tool Company, of which he was general manager, to accept his new position.

Burns has been identified with the oil tool industry for more than 15 years and is considered an authority on the design, operation, and manufacture of many classes of oil tools and equipment. He has been active for several years in co-operating with oil companies and other tool manufacturing companies in establishing uniform standards and trade practices.

John Grant will leave on April 4 for New York, enroute to Europe. He will be abroad for two months or more and will visit the head offices of oil companies in London, The Hague, Paris, and Roumania. Mrs. Grant will accompany him.

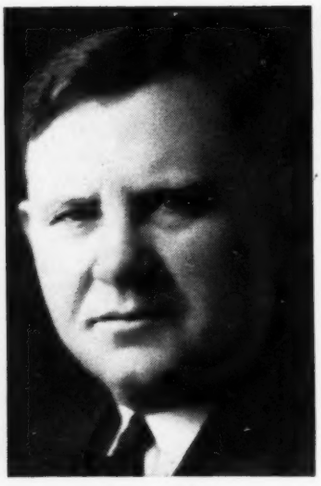
Harry Hester continues as comptroller and credit manager, with headquarters at the office and factory at 2042 East Vernon Avenue, Los Angeles, California.

Union Wire Rope Corporation Elects Officers and Directors



R. H. BARTLETT

M. G. ENSINGER



H. R. GRUBER

J. H. HATCH

Directors of the Union Wire Rope Corporation, at their annual meeting March 24th, feeling that the company's consistent growth rendered advisable an enlarged executive staff, created the new position of chairman of the board. R. H. Bartlett, who has been president of the corporation since its organization, was advanced to the position of chairman of the board, and M. G. Ensinger, who has been vice-president and general manager, was advanced to the position of president and general manager.

Officers and directors elected for the coming year are: R. H. Bartlett, of Tulsa, president Bartlett Oil Corporation, and director The Fourth National Bank of Tulsa, chairman of the board; M. G. Ensinger, Kansas City, president and general manager; H. R. Gruber, Tulsa, vice-president and sales manager; J. H. Hatch, Kansas City, secretary and treasurer; J. C. Soll, Kansas City, assistant secretary and treasurer; H. M. Lawrence, Tulsa, assistant secretary and treasurer; Directors: R. H. Bartlett, M. G. Ensinger, H. R. Gruber, Frank L. Moore, Tulsa, independent oil operator and director Mid-Continent Petroleum Corporation, H. O. McClure, Tulsa, president The Fourth National Bank of Tulsa, E. A. Reedy, Kansas City, vice-president Schermerhorn Bros. Co., Phil D. Morelock, of Shouse, Morelock & Shrader, attorneys and tax counselors of Kansas City, Tulsa, and Washington, D. C.

The AUTOMATIC WATCHMAN

CUTS LABOR COST TO MINIMUM

In addition to automatic operation — from the well or wet oil tanks to dry stock—each individual Petreco Electromatic dehydrating unit is equipped with a signal light near the top which serves as an automatic attendant, constantly watching over and indicating the "cut" on the treated oil. Any change in the operating procedure or in the cut of the treated oil, however slight, is indicated immediately by this infallible attendant that is clearly visible at a considerable distance and is always on the job.

The advantages of such features of Petreco Electromatic Dehydration are of outstanding importance. Less plant supervision is necessary. The cost of labor is less than for any other method of treating. Uniform cut, and plant performance, are precisely maintained. Savings throughout the entire electromatic dehydrating procedure reduce over-all treating costs to absolute minimum.

Complete information relative to Petreco Electromatic Dehydration of crude oil emulsions will be supplied to any operating oil company on request.

PETROLEUM RECTIFYING COMPANY OF CALIFORNIA

General Offices: 530 W. Sixth St., Los Angeles, Calif., U.S.A.
Branch Office: Houston, Texas. Branches and Service Men in Principal Oil Fields.

PETRECO

10 PROFIT MAKING TOOLS
YOU SHOULD SEE WHEN YOU'RE IN HOUSTON

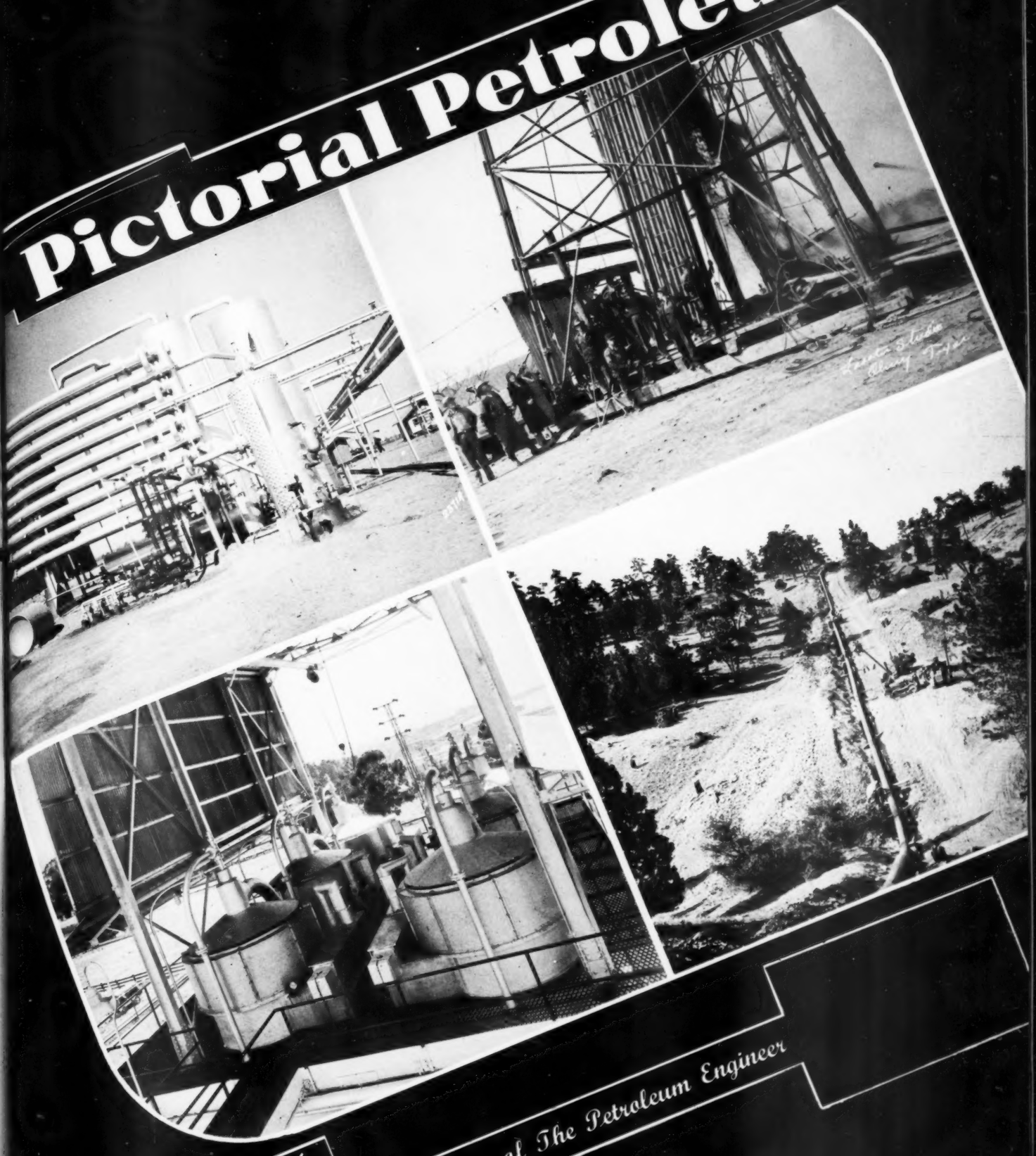
When you are in Houston visit our headquarters at 5116 Navigation Blvd. A hearty welcome awaits you. Here you can get the complete story on all the famous MacClatchie Tools.

1. MacCLATCHIE SPECIAL TAPER ROD—A universal rod with a rod nut of such taper and so designed as to automatically tighten on rod threads and insure a firm grip on the piston.
2. "WEAREVER" PUMP PISTONS—Designed so that wear is absorbed by the rubbers, which are economically replaced for less than half the cost of a new piston.
3. MacCLATCHIE "MONEY-SAVER" PUMP LINERS—The low first cost and replacement cost will surprise you.
4. MacCLATCHIE MUD PUMP VALVES—Made of drop forged steel. The seats are accurately ground, wrapped in oil paper and individually sealed in heavy cartons. Cut-out mud ends are unknown to users of MacClatchie Valves. The world's largest selling valve.
5. MacCLATCHIE QUICK CHANGE CEMENT HEADS—the speediest and most convenient unit for cementing and running in casing. May be installed in less than 30 seconds and can be removed in even less time.
6. MacCLATCHIE QUICK UNIONS—This union comprises an elbow, a nipple and a yoke. Provides a safe, sure connection, useful wherever speed is required. Thousands are in use throughout the world—on cement heads, circulating heads, rotary swivels, suction lines, stand-pipes, fire hydrants, loading racks and tank cars.
7. HYDRO-SEAL PLUG VALVES—The greatest improvement in plug valve design in 70 years. This valve employs no packing, thereby eliminating friction caused by packing glands and packing.
8. GEAROMATIC CATHEAD—Operates on a new principle. It gives twice the power at half the speed—breaking the tighest joints with ease—without damage to tongs, tong dies, pipe or other equipment. There is no friction clutch nor costly bearings and the entire cathead is lubricated from one Alemite nipple. Absolutely guaranteed to break all 8-inch drill pipe joints and all bits and drill collars with ease.
9. ROTATING BLOWOUT PREVENTER—(For drilling under any mud or gas pressure.) Will withstand any pressure encountered in present day drilling. Its construction is so rugged and its design so simple that it will stand up under extremely hard usage. Quickly and conveniently operated from the derrick floor and may be rotated day after day without undue wear. Made for all sizes of Kellys and casing.
10. MacCLATCHIE WALL SCRAPER—The remarkable performance of this tool is due to its three cutters, which insure a true circular bore. This three cutter assembly makes a stronger body which stands the gaff.

MacClatchie
MANUFACTURING COMPANY

Compton, California • Houston, Texas • Export, George R. Wilson, 17 Battery Place, N. Y. C.

Pictorial Petroleum

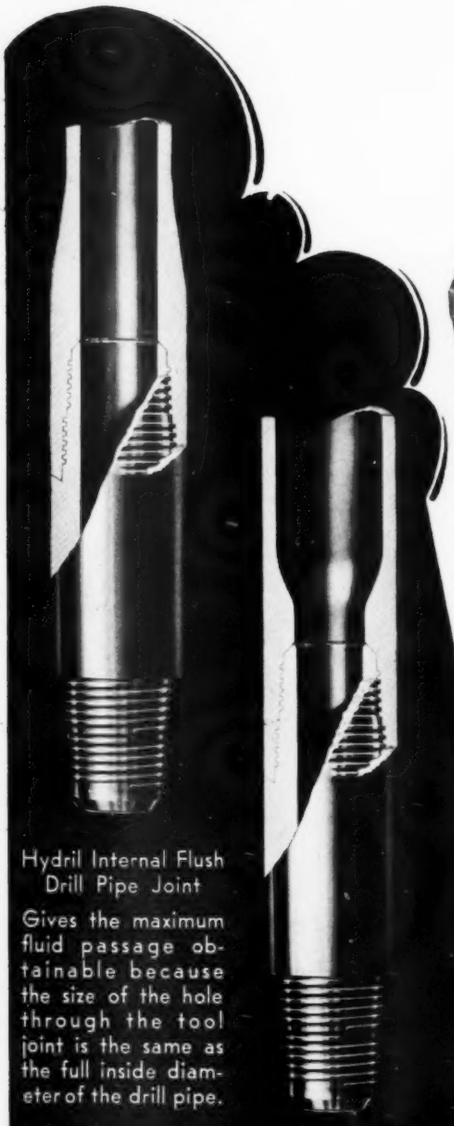


april 1936

A Regular Feature of The Petroleum Engineer

IDECO

HYDRIL
Drill Pipe Joints



Hydril Internal Flush Drill Pipe Joint

Gives the maximum fluid passage obtainable because the size of the hole through the tool joint is the same as the full inside diameter of the drill pipe.

Hydril External Flush Drill Pipe Joint

Essential for Safety, Speed and Economy in all controlled-pressure drilling operations. Offers many advantages in ordinary drilling work as well.

This Testing Machine Proves **Every Drill Pipe and Tool Joint Thread** *before delivery to you . . .*

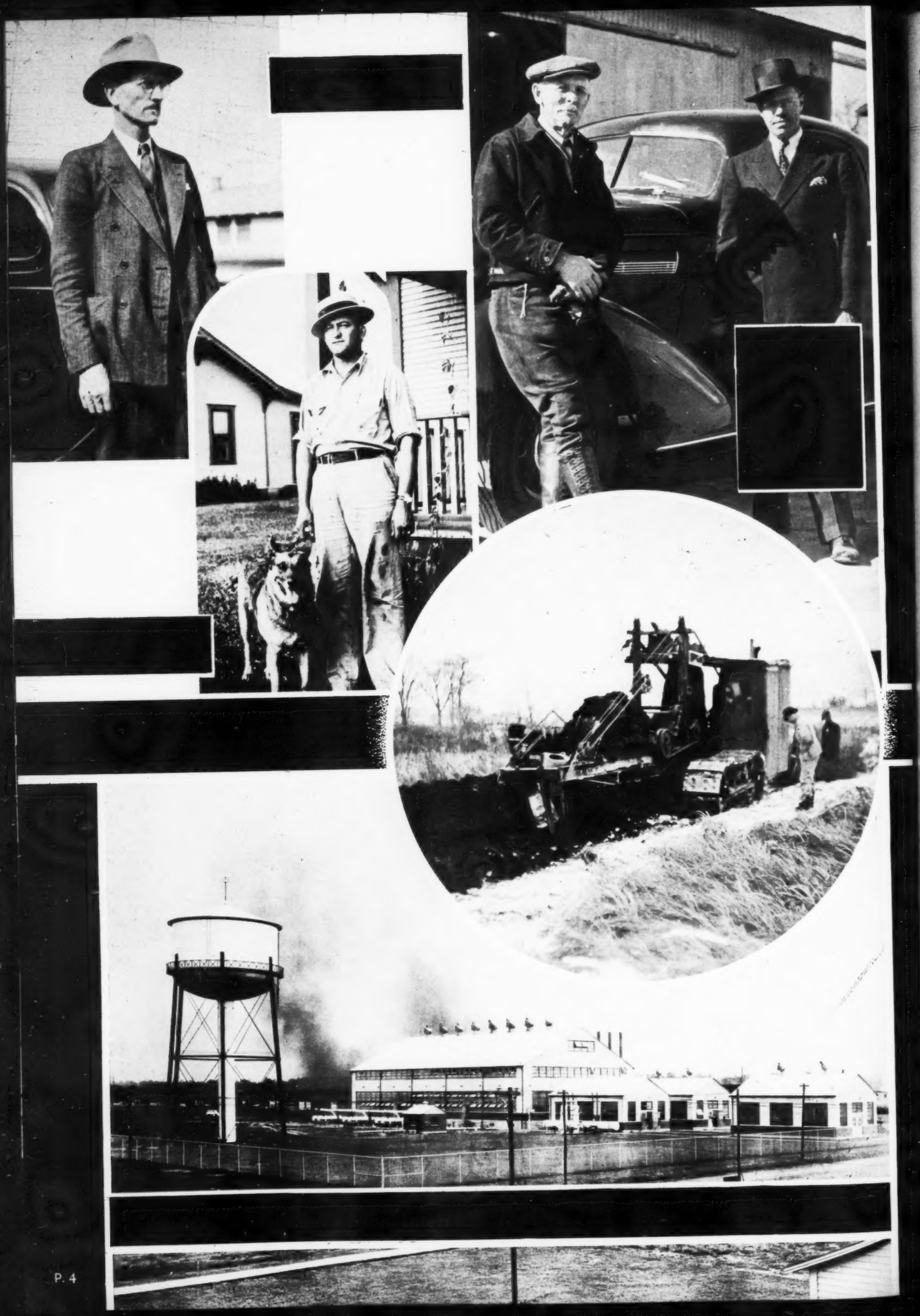
You *can't* be too particular about drill pipe joints. Too much depends on their being right in every way. We are particular, too; we *prove* every drill pipe joint we make—not once, but many times—before the tool joint is finally correctly made up in the pipe and delivered to you. This is the way it's done: As shown in the picture, a finished joint of pipe is passed through the hollow spindle and secured in the jaws of a special torque-measuring machine developed by Hydril engineers. The machine is set in motion and the tool joint, treated with a standard thread lubricant, is screwed into the pipe. Gauges on the machine and on the tongs tell the operators when the torque exerted by the machine is greater than the joint will ever be subjected to in drilling. The joint is then unscrewed and both the pipe and tool joint threads are carefully inspected. The process of setting up and breaking out the joint is repeated several times before the tool joint is finally made up and left in the pipe. (The design of this non-creeping, non-leaking joint eliminates the necessity for welding the tool joint in the pipe.) In the same way the other end of the tool joint and the next length of pipe are tested together, and so on until every joint in your new string of drill pipe has thoroughly proved itself.

Is it any wonder that operators throughout the world who demand the utmost in dependability, endurance and smooth performance specify Hydril Drill Pipe Joints?

NOTE: *All manufacturers of seamless drill pipe make pipe for both Hydril Internal Flush and External Flush Drill Pipe Joints. Threads are cut in the drill pipe and tool joints manufactured at the Hydril factories in Torrance, California, and Houston, Texas.*

HYDRIL COMPANY

714 West Olympic Boulevard • Los Angeles
4300 Calhoun Road • Houston, Texas
Cable Address "HYDRIL"

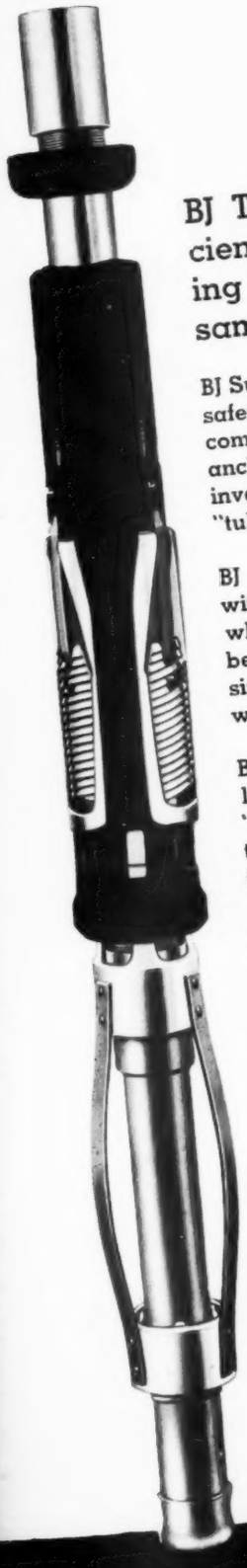


BJ

these

EFFICIENCY GOES UP

COSTS COME DOWN



THESE ADVANCED BJ Tools are bringing safety, efficiency, and savings to many leading operators — they will do the same for you.

BJ Surestop Tubing Catchers (left) afford complete safety to your tubing strings while running-in, coming-out, or suspended in the well. When anchored in the casing, production is almost invariably increased and collar wear due to "tubing breathing" is completely eliminated.

BJ Tubing Hooks are made with the "BJ Locking Arm," which provides safety never before available. Made in 3 sizes for 30, 50, 75-ton safe weight load.

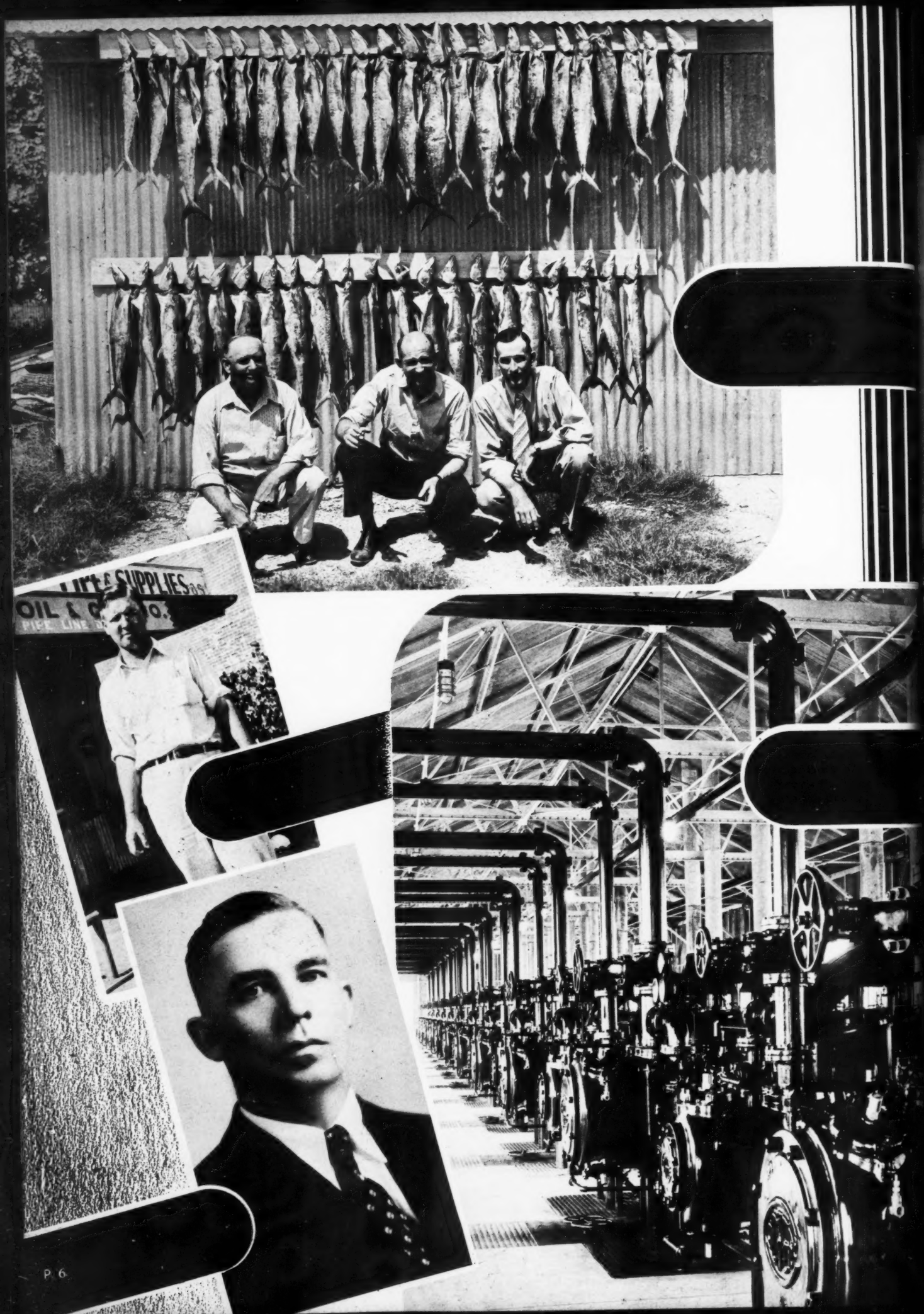
BJ Rod Hooks are made for 10, 15 or 20 tons of rods. The "20 Spring" Hook (at extreme right) is the outstanding choice for long strings.

BJ Rod Elevators are reversible top and bottom, and are equipped with front and rear operating latches. The combination (illustrated below) is the last word for fast, safe rod jobs.

For full particulars refer to the BJ Section on pages 288 to 352 of your 1936 Composite Catalog, or write for the 1936 BJ Catalog.

BYRON JACKSON CO.
AND SUBSIDIARY
FORT WORTH • LOS ANGELES • NEW YORK

TOOLS

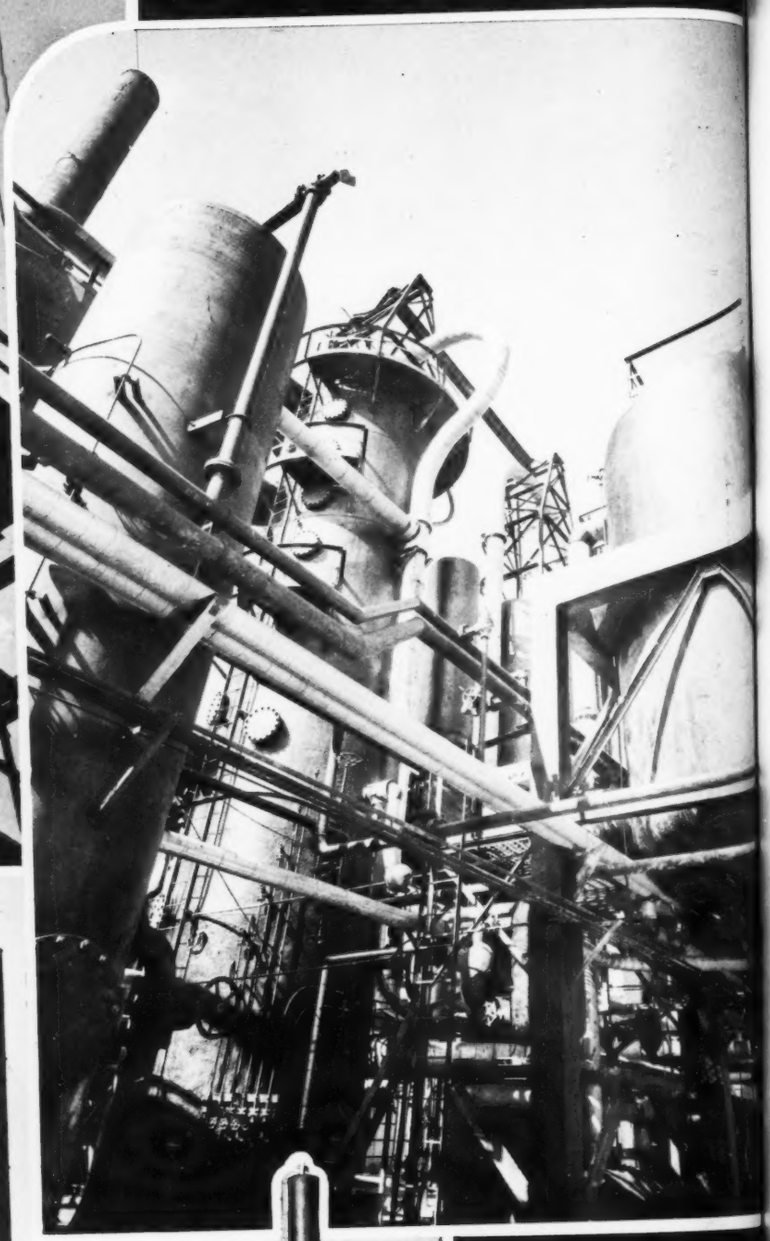

SUPPLIES
OIL &
PIPE LINE

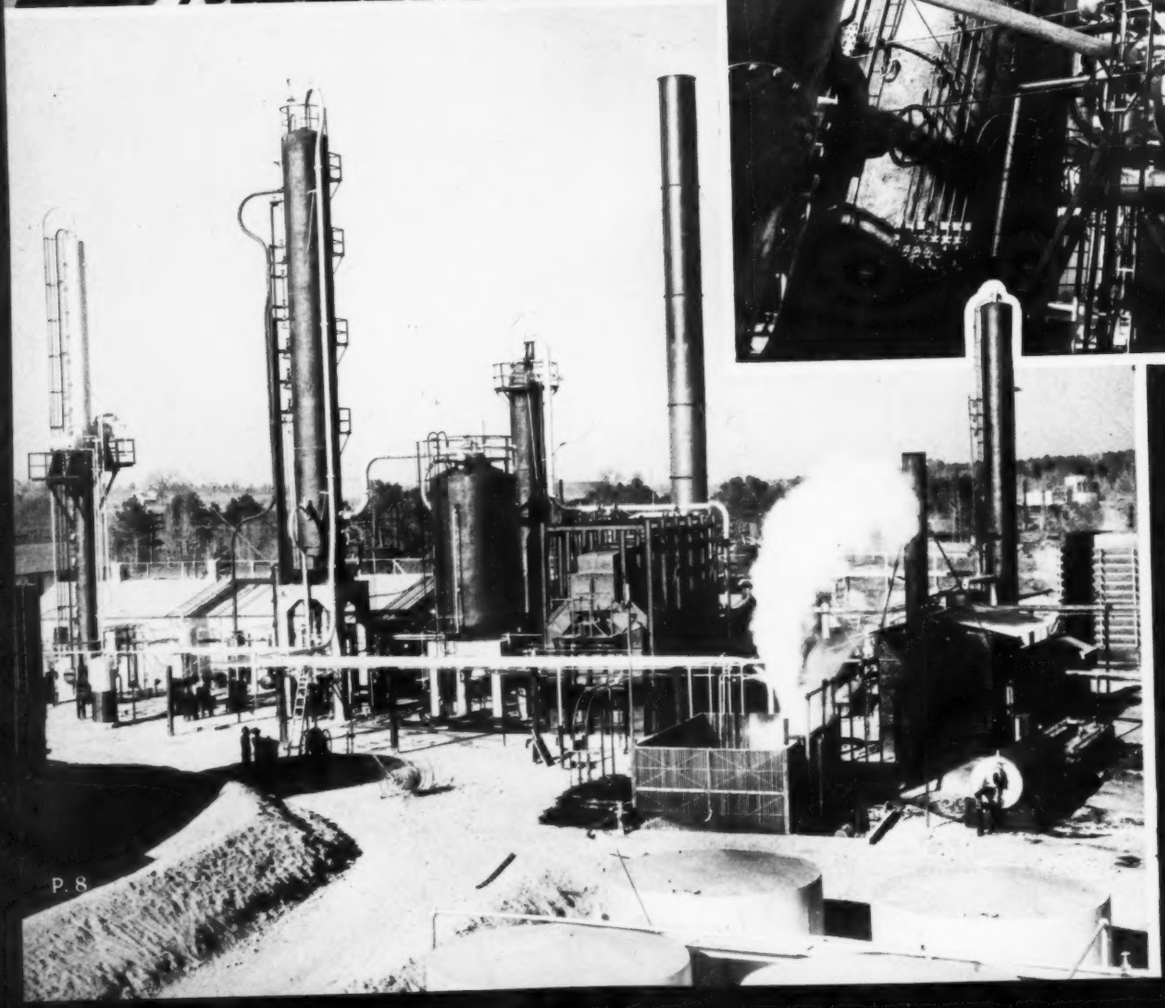
PLAN NOW TO ATTEND

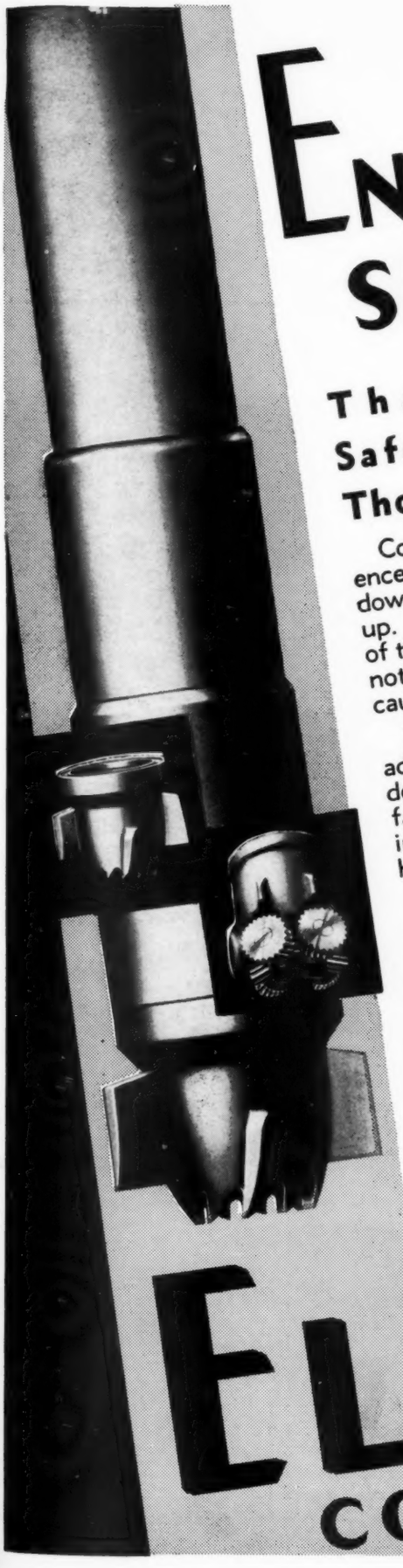
9th INTERNATIONAL PETROLEUM EXPOSITION

TULSA May 16-23, 1936

The World's Fair of the Oil Industry







ENGINEERED SIMPLICITY

That Is Essential To Safe, Dependable Operation Thousands of Feet Underground

Coring wisdom is developed through long experience, and experience teaches that as the drill goes down the hazards increase and the monetary risk goes up. Every man around an oil well knows that the cost of the tool at the bottom end of a mile of drill pipe is nothing as compared to the cost of delays and losses caused by accidents and failures in operation.

To guard against these hazards Elliott always has adhered rigidly to a policy of extreme simplicity in the design and manufacture of Elliott Core Drills; steadfastly refusing to incorporate any features or "gadgets" in these tools which might jeopardize their traditional high factor of safety and dependability in service.

Fifteen years of intensive specialization in coring oil wells and the manufacture of coring equipment enable Elliott to provide the oil industry with the simplest, safest, most dependable core drill that able engineering, practical experience, fine materials, and precision manufacture can produce. Current models of Elliott Core Drills embody these ideals in the highest degree and assure high recoveries of good cores from any formation, in any well, in any oil field in the world.

Write for Bulletin No. 36-R

ELLIOTT CORE DRILLING COMPANY
4731 East 52nd Drive Los Angeles, California, U.S.A.
Export Office: 1215 Graybar Bldg., New York City.

ELLIOTT
CORE DRILLS

Engineering Fundamentals Department

- A Study Course for Field and Plant Men
- A Review for Experienced Engineers

W. L. NELSON
K. C. SCLATER
Editors

Elements of Applied Petroleum Production

By K. C. SCLATER

Article 30 (Concluding)

OILFIELD EMULSIONS (Continued)

OILFIELD emulsions[127] are commonly referred to as "cut oil", "wet oil", or sometimes as "B.S." The determination of the type of an emulsion is extremely simple—if it can be mixed with water it is an emulsion of oil in water; if it can be mixed with oil it is water dispersed in oil. Probably more than 95 percent of all oilfield emulsions are of the water-in-oil type.[128] It is this latter type, with which the man in the field is chiefly concerned.

Oilfield emulsions may for simplicity be divided into three general classes, according to how they appear after hand-centrifuging.[128]

1. Those that show only water and clear oil. Emulsions of this class usually can be separated without chemical treating by allowing them to stand. Some emulsions, especially diluted with gasoline, separate in oil and water in the centrifuge, but will not separate in the field without chemical treatment.
2. Those that show emulsion, with or without water, and clear oil. An emulsion that behaves in the centrifuge in this manner is a true emulsion and chemical treatment is necessary for dehydration.
3. Those that may or may not show emulsion and water but that also show cloudy after centrifuging.

Crude oils with an asphaltic base[129] are more susceptible to the formation of emulsion than paraffin-base crudes.

In order for the oil to be accepted by the pipe line or company purchasing the oil, the B.S. and W. content must not exceed a certain maximum—usually in the neighborhood of two percent or less.

Though the practices employed in treating emulsions in the field are quite varied, they all can be classified under: 1. Heating; 2. Filtration; 3. Chemical treatment; 4. Electrical treatment; 5. Centrifuge treatment.

Any one or combination of the methods mentioned may be and are employed in the field. The type of emulsion and the local field conditions will determine the most suitable method or methods to adopt.

Since oil to be acceptable to the pipe line or company purchasing must have a B.S. & W. content of usually less than two percent, economical methods of treating an emulsion in the field are necessary. They are an important factor in lease economy.[130]

The means and equipment for reducing emulsions in the field are quite varied.[131, 132, 133, 134] Heating is widely used either alone or with the use of chemicals.[135] On leases of small production, plants of 80 to 100 bbl. daily capacity for treating emulsions by heat and chemicals are not uncommon.[136]

Electrical methods[137, 138] of treating crude oils are employed on a large scale in many districts where refractory emulsions are present in large volume.

PRODUCTION RECORDS

Good production records are essential to the efficient operation of wells and of oilfields in general. Most of the information that enters a field record is obtained by the man in the field. It is to his interest therefore to acquaint himself with the need for good records and the important part they play in fostering good production practice.

Production records can be classified under two heads according to the specific purposes for which the records are used. They are:

a. Records required by the management for general accounting purposes.

b. Records used by company officials and men in the field for operating purposes.

It is the latter type of record with which we are here chiefly concerned.

Operating records will vary in number and kind according to field needs. The depth and type of wells usually will determine the adequacy and type of records that should be used. Obviously, records for a shallow field composed of stripper wells will be quite different from those for a deep field composed of flowing wells in the flush stage of production. Whatever the form and number of production records adopted for use they should provide reasonably exact and adequate information essential to efficient operation. In general, such essential information should cover:

1. The rate, and quantity of production from each well. In most cases, it will be preferable to make this a daily

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record. It should show the quantity of oil, gas, and water, and the gravity of the oil produced.

2. Operating conditions in each well. On this record will be shown information such as the method of production, casing and tubing pressures, any observed peculiarities of the well while flowing or pumping, the formation of emulsions and any bottom-hole information regarding temperature and pressure. The frequency of this report may be daily, weekly, monthly, or some other regular interval depending on the type of well and its operating characteristics.

3. Repairs and changes (in detail) made on each well. When a well is shut down for repairs or to make a change, a careful record should be made of the repairs or changes made. This information should be shown in as much detail as possible and convey adequate information on the cause of the shut down. This is an important record and when properly filled the information becomes invaluable in analyzing well troubles.

4. Equipment and its condition at and in each well. An accurate record should be kept of the equipment in the well and at the surface. This should include information such as depth and size of tubing, depth of pump, size and length of anchor, type and location of packers or tubing anchors, casinghead connections, size and type of flow bean, and power equipment. By means of this record the equipment in and at each well is known at all times. It is especially important to know what equipment is in the well in case of changing the depth of the flow-tubing, the pump, or any special equipment in the well.

If secondary recovery methods such as repressuring or water-flooding are used, special records may be required to show other information such as the input and injection pressure of gas, air, or water into key wells daily.

Efficient control of production can be attained only by employing an adequate system of records. It is by means of production records that the results of changes in a well's behavior can be observed. The importance of good records, especially technical records, are universally recognized.[139] An adequate record does not mean necessarily a complicated record. The simpler the records are the better, for then they are likely to be more fully utilized.

"Records form the basis for the successful operation of any company. The expense of compiling records is negligible in comparison with the need of records and the results obtained by their use. * * * The records needed vary with each district, and for each field a set should be adopted that will best meet the needs of each property.

"Practically all operators, and particularly all successful operators, agree on the necessity of good records—records that tell what the wells have done, are doing, and may be expected to do. Every operator realizes the value of records of sales of oil and should place almost equal value on records of well logs and on histories of the past and present performances of wells."[140]

A series of recommended forms comprising one set covering Mid-Continent-Eastern practice and another set covering California practice have been issued by the Production Division of The American Petroleum Institute.[141]

Good production records also are of importance for purposes of cost-accounting—the phase of accounting that has to do with determining the cost of the various operations involved in producing oil.[142]

CO-OPERATIVE METHODS OF PRODUCTION

An oil pool is a common reservoir of oil, gas, and gas energy. As each producing well in an oil pool is drawing from one common source of oil, gas, and gas energy, the ultimate production obtainable from the pool will depend on how the various wells are operated. Improper completion or bad production methods at one or more wells will be harmful to the other wells in the pool and may result eventually in high lifting costs and low ultimate recovery. If the ownership of the wells is divided among various companies such a thing may happen unless there is coöperation of some kind among the companies.

In recent years operators have become more enlightened regarding changing conditions in the reservoir as the oil and gas are produced. It now is realized that undue dissipation of gas energy eventually shortens the life of the pool. That is why we hear today so much about declining bottom-hole pressure in connection with the withdrawal of oil and gas. Too rapid a decline of bottom-hole pressure may be indicative of wasteful production practice or too rapid a rate of withdrawal. With all the available knowledge and methods of subsurface measurements in wells at our command today the need for coöperative methods of oil-pool development is much more evident than heretofore.

Except for the economic factor of market price of the crude oil, the factors that determine how best to develop an oil pool are those relating to reservoir conditions. On these should be based the best methods of producing the wells, and such methods adhered to closely by all operators in the pool. In other words, the pool should be produced as a unit so that all may receive equal benefit.

It is this general desire for obtaining the greatest ultimate recovery from a pool at the lowest cost per barrel that has given rise to the increasing trend toward coöperative development and so-called unitization of oil pools.

All unitization projects have as their aim the operation of an oil pool as a unit. There are many engineering and economic questions to be considered in unit operation. Compared with competitive methods of the destructive, the industry abounds with evidence of the much greater benefits to be derived from unit operation.[144] There are also great economies of operation possible.[145]

Some of the most notable examples of unitization are those in oil pools controlled or owned entirely by one company.[146, 147] Many old oil pools have been unitized in recent years for the purpose of putting into effect a repressuring program. One of the most recent of these involving a number of operators is the Burbank pool in Oklahoma.[148]

In a unitization project where several companies are concerned, all producing operations are usually carried on by only one of the operating companies, assisted by a committee of engineers or officials of the other companies. Although the details of the method used in managing and operating a unitized pool vary quite widely, they all have as their object coöperative action to insure maximum equitable ultimate returns from the respective properties involved. Adjustment provisions are desirable in unitization agreements.[149]

Coöperative operation of a pool may be carried on by general agreement among the operators. Each operates his own property but produces his wells in accordance with certain rules agreed on by all operators in the pool. These rules should have to do principally with maintaining reservoir conditions that will result in the greatest benefit to the pool. Particularly should limitations be placed on the expenditure of gas energy per barrel of oil produced. State conservation regulations in some states with regard to good production practices, combined with the regulations on proration, have aided greatly in fostering coöperative operation of oil pools.

PRORATION

Continued production of oil in excess of the market demand brought about the need for prorating the market outlet among the different fields in the United States. Such allocation of petroleum production is termed "Proration" and is so known today in the oil industry. First started as a voluntary movement among operators, proration now is enforced by most oil-producing states.

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The present wave of proration started about ten years ago (1927) in Oklahoma. Proration in these early days was by purely arbitrary methods. Since then the methods of allocating production have gradually changed. Efforts are constantly being made to reach more exact methods of determining allowables between wells and between fields that will be more equitable and give to each owner his just share of the oil, gas, and gas energy in a pool.

There are two phases of the problem. One is the allocation of production among fields and the other the allocation of production among the wells in a pool. The man in the field is chiefly concerned with the latter.

To date the dominant factor used in determining allowable production, either for fields or wells, has been the potential production. "Potentials" are usually determined from flow tests made in the field according to certain procedure and under certain stipulated regulations and conditions. These regulations vary widely according to the locality and the type of oil pool. "Potential" is a confusing term.[150] It is generally considered to be the maximum rate at which a field or well can produce. Thus potentials are used as measures for allocating production. No consideration is given to the question of how long the potential rate of flow can be maintained, although the reservoir conditions determine this.

In the light of available technical knowledge of subsurface oilfield development, this is a more or less arbitrary method of allocating production. Proration should be based on oil content and the rate at which a pool or reservoir can produce without undue waste of natural energy, such as that derived from gas under pressure or water drive.

Some studies have been made on the effect of proration on the production of oil wells and it has been shown that in some wells, especially edge wells, unless favorably situated on the structure, the ultimate recovery will be decreased.[151]

Proration on the basis of energy has been suggested.[152] Under the system the total available energy of the pool would be determined and a production program outlined accordingly. By prorating the available energy the pressure throughout the reservoir could be maintained approximately uniform and thus prevent migration of oil from one property to another. This would assure each operator of getting his just share of the oil, gas, and gas energy in the pool.

Another method suggests proration on the basis of gas withdrawal.[153] Under this method gas, rather than oil, would be "removed at as nearly a uniform rate as possible per unit of area. An oil field would be divided into groups of unit areas according to competitive conditions and position on structure, with the groups so selected that sub-surface conditions therein are nearly uniform and so that oil and gas production within a group can be prorated on an acreage basis." By producing equal quantities of gas per unit area during the flush period of production great benefits would result.

Still another interesting method of proration proposed is that by pressure control.[154] There are still others.[155]

How long proration will continue in force in the oil industry is a question. Under proration the industry has made great progress in methods of production. This is the direct result of having been able to make field observations on subsurface conditions in active oilfields, an opportunity that probably would not have presented itself for some years had proration not been in effect in these fields. East Texas field is an excellent example. Despite the difficulties encountered in enforcing proration, this field has been and will continue to be a source of valuable information on what takes place in the reservoir as the oil is withdrawn.[156] Proration in that field has awakened the industry to the benefits that can result from controlled production.

[EDITOR'S NOTE: This article concludes the series on Elements of Applied Petroleum Production.]

QUESTIONS

1. What types of crude oils are susceptible to the formation of emulsions?
2. Describe some simple type of field plant for treating emulsions.
3. Why is a good set of records essential to efficient producing operations?
4. What type of records and information might be used for a group of stripper wells?
5. What is meant by unitization of an oil pool?
6. What is the purpose of unitization?
7. What benefits are to be obtained by unitization?
8. In what respects does coöperative operation differ from unitization?
9. What is proration? Its object?
10. What is generally meant by "Potential"?
11. Explain the system of proration based on "Potential."
12. Explain any other systems of proration with which you are acquainted.

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Elements of Applied Petroleum Pipe Line Transportation

By C. E. MAIN, Sr.
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Article 21
(Concluding)

FLOW OF LIQUIDS IN PIPE LINES (Part X)

Discussion of the Experimental Chezy Friction Factors

In the articles thus far published, commencing with the July, 1935, issue of *The Petroleum Engineer*, the writer first gave the derivation of the two basic formulae, the Chezy and the Hagen, of which all hydraulic flow equations are an adaptation of one or the other. Then, the application of the Chezy formula, including each step of the computations necessary for the complete solution of a practical problem, was given, following which was discussed the application of the Hagen formula, including each step of the computations necessary for the complete solution of the same problem used in the previous articles.

In these articles considerable stress has been laid upon several important fundamental principles that heretofore have been misused, and they have resulted in the experimental friction factors being made to include these various inconsistencies.

Let us first consider the following transposition of the Chezy formula No. 15, solving for the experimental friction factor. If the friction factor is to be considered as some function of the argument, its relation also will be shown.

$$(f\mu) = \frac{2gh\,D^5\,N^2}{5181\,M\,B^2} = \frac{X}{\left(\frac{B}{DKN}\right)^{2-n}}$$

$$\log \text{ of } 5181 = 3.7143905$$

Each factor involved in the equation is analyzed for its effect upon the Chezy experimental friction factor when its values contain possible errors, due not only to the method of measuring the experimental value, but to the application of this equation to piping layouts (parallel lines of different diameters) that is entirely beyond its application.

If we analyze this equation in its application to single-line flow, it is possible to procure scientific results when careful measurements are taken during the experiment.

For instance, factor g, the acceleration due to gravity, may be obtained with such accuracy that the effect of its error on $(f\mu)$ is negligible for any given location. But if 32.16 is taken as a constant and is incorporated in the coefficient 5181, then the error in g may effect the experimental friction factor approximately one-seventh of one percent.

The effective head h is somewhat difficult to obtain since it depends upon the gravity of the liquid, the accuracy of the elevations of the pressure gauges at each of the locations, and upon the accuracy of the pressure gauges as well as the readings of the gauges. The permissible error in h, due to the several elements mentioned, is usually exceeded in the most exacting measurements so that its effect upon $(f\mu)$ may be as small as one-half of one percent plus or minus. By the ordinary method of obtaining the experimental value of h, an error of only two percent, plus or minus, in $(f\mu)$ would be hard to attain, whereas the error in $(f\mu)$ is very likely to be eight percent plus or minus.

Upon first thought the error in the diameter D may seem negligible. However, an error of only 0.019 of an in. in the diameter of an 8-in. pipe will affect the experimental friction factor 1.2 percent. A reduction of the diameter due to paraffin collections on the inside of the pipe may give a very large percent of error in the experimental friction factor.

When N represents the actual number of lines of exactly the same inside diameter, the value of $(f\mu)$ cannot be affected in any way, although if N represents the equivalent number of a chosen diameter based upon some arbitrary exponents in the equation of pipe diameters, there is no possible way of determining the percent of error in $(f\mu)$ due to the error in N since these exponents should have the values shown by the experimental friction factors and the experimental friction factors are yet unknown.

To give some idea of this error, let us compute by Equation 10 the number of pipes of one size equivalent in carrying capacity to a larger diameter pipe by using the familiar exponent 2.5 and again by the exponent 2.714:

$$N_1 = \left(\frac{D_1}{D_0}\right)^m = \left(\frac{7.981}{12.0}\right)^{2.5} = 0.36074$$

$$N_2 = \left(\frac{7.981}{12.0}\right)^{2.714} = 0.33055$$

and

$$\left(\frac{.36074}{.33055}\right)^2 = 1.191$$

or 19.1 percent difference in the experimental friction factor due entirely to not knowing the correct value of the exponent m to use for the experiments made upon parallel line flow. The value of $m = 2.714$ is not scientific in value, however, it appears to approximate the probable value according to the many friction factor curves now in the hydraulic literature.

If M represents the actual length of one line, or the actual length of several parallel lines of exactly the same inside diameter in one section of piping, then the ordinary careful chaining of the line will give errors in M too small to have any appreciable effect upon the experimental friction factor.

In the Chezy equation of the equivalent length of a section

$$M_0 = \frac{M\,D_0^{2m}}{(D_1^m + D_2^m + D_3^m)^2}$$

if arbitrary values are used for the exponents instead of the values shown by the experimental values of the friction factors (which values are unknown) the error in M may have a serious effect upon the experimental friction factors. This may be shown by the following illustration: first, by taking the value of the exponent $m = 2.5$, the familiar square root of the fifth power of the diameter; second, by considering

the approximate value of $m = 2.714$, and, third, by taking the equivalent length direct from the Heltzel table (p. 81, May 10th, 1934, issue, *Oil and Gas Journal*).

These three values are 7.684, 9.152, and 6.875 miles, respectively, and the error in $(f\mu)$ based upon the second value as being the most probable as shown by the various friction factor curves (pp. 82-83, August issue *The Petroleum Engineer*) that have been published in the hydraulic literature, we find by using the first instead of the second value of M an error in the experimental friction factor of 19.1 percent and by using the third instead of the second value of M an error in the experimental value of the friction factor of 33.1 percent.

The discharge B in bbl. per hr. is the most difficult to measure of all the other factors in the Chezy formula, as may be seen from the following remarks:

First—During the interval of time of the experiment the pressure must be held absolutely constant so that the flow is uniform throughout the time of the experiment.

Second—The flow should be gauged at the station pumping as well as at the receiving station. This necessitates at least four tank gauges, and if the reading is taken to the nearest one-eighth in. a 13 to 20 bbl. error is likely in the matter of gauging alone.

Third—The temperature-volume effect upon the flow during the interval of the experiment may represent quite an error. For instance, the difference in the average temperature of the oil in the receiving tank and incoming oil may be several degrees, and the same is possible at the discharge tank. Then, too, the oil that is gauged at both ends of the district may not represent the actual oil flowing during the experiment, especially if the experiment is on one section of the district.

If the tank table is based upon strapping measurements taken in the summer when the sunny side of the tank is extremely hot and the experiments made when the shell is much colder, the error in the tank table may amount to several barrels.

The unknown error in determining the discharge in bbl. per hr. may affect the value of the friction factor ten percent, although a smaller percent is possible if the duration of the experiment is increased to several hours, provided a uniform flow can be maintained during the longer experiment.

The oil samples and temperatures should be taken at both manifolds and at each intermediate gate plant. These samples are used to determine the observed gravity (A.P.I. deg.) and the viscosity at the temperature of the oil flowing in the line. If there is any appreciable difference in the viscosity at the several locations, the experiments should be thrown out inasmuch as the average value cannot represent the true value and this difference may result in a large error in the experimental friction factor.

These brief remarks regarding the errors in the experimental friction factors due to errors in the measurement of the several factors of the Chezy formula should cause every engineer to hesitate before accepting blindly experimental friction factors and their corresponding arguments or criterions, especially when it is not definitely known that they were obtained from single line flow.

Experimental values of the Chezy friction factors obtained from parallel line flow experiments, especially when the equivalent length of each section are added together for the equivalent length of the entire station district, and when the equivalent number of lines of the chosen diameter in each section are not made a factor of the argument, they are without any semblance of value.

It is to be hoped that the rough and tumble methods of obtaining the so-called experimental Chezy friction factors, together with their corresponding arguments or criterions, will be discontinued, also that the dispatcher's daily pumping sheet will be ignored completely and hereafter all experimental data be obtained from actual experiments taken upon single line flow. These experiments should be made only after the line has been cleaned, all pressure gauges checked carefully with the master gauge, provisions made for taking samples, and a special water glass sectional gauge attached to the working tanks for reading the in- and out-flowing oil to the nearest hundredths of an inch.

This class of experiments would give values of the experimental friction factor and their corresponding arguments that would have some mathematical relation. It is true that hydraulic experiments of value require considerable time and expense and both are usually hard to obtain by the pipe line engineer, yet he is expected to have knowledge concerning an empirical subject that depends entirely upon experimental results.

Other departments in nearly all companies have more or less money for experimental purposes, and if a little were available for hydraulic experiments the engineers of the American pipe line companies could, in a very short time, produce trustworthy experiments that would no doubt be the means of developing a true law of flow of viscous liquids in pipe lines.

[Editor's Note: This article concludes the series on Elements of Petroleum Pipe Line Transportation.]

Petroleum Reserves Discovered in 1935 Estimated at 1,810,000,000 Barrels

It is entirely possible that the important question in the future may not be "how long will our supply of oil last?" but rather "how can we make use of our supply of oil", Axtell J. Byles, president of the American Petroleum Institute, declares in an article appearing in the current issue of the "Mines Magazine," a special petroleum number.

New petroleum reserves uncovered during 1935 amounted to 1,810,000,000 bbl., Mr. Byles states. "In all, 40 new fields were discovered in the first nine months of last year, a fact that should give assurance to those whom the prophets of petroleum exhaustion may have dismayed."

He puts the developed reserves as of January 1, 1935, at 12,177,000,000 bbl., and says, "In connection with future discoveries, it must be remembered more than 1,000,000,000 acres of geological formation in which oil may be found remain unexplored—a much larger area than already has been examined by the best current methods."

"In its refusal to accept a dictum of doom with respect to motor fuel resources, the petroleum industry is vividly aware of the existence of other sources: in coal, lignite, and shales," Mr. Byles declares. He believes the hydrogenation process of coal conversion offers bright promise from the standpoint of motor fuel supplies to supplant petroleum when needed.

Motor fuel can be produced from coal, even on a limited capacity production, at a cost of 10 cents to 15 cents a gal., he asserts, and in England, where this process has been highly developed, yields of from 90 to 140 gal. of crude oil have been obtained from a short ton of coal, which indicates that "untold thousands of billions of gallons of motor fuel await extraction by the hydrogenation process in the unlimited coal reserves of this country should it ever become necessary to resort to them."

The "Mines Magazine" in which Mr. Byles' article appears, is the official organ of the Colorado School of Mines Alumni Association. The School of Mines is one of the few universities in the country offering special courses in petroleum engineering.

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Elements of Applied Petroleum Refining

By W. L. NELSON, Consultant*

CENTRIFUGAL PUMPS AND THEIR USES IN THE REFINERY

Article XXX (Concluding)

RECIPROCATING pumps such as those discussed in Article XXIX, March, 1936, have been the most widely used refinery pumps, but recently centrifugal pumps have been installed for many new services and in the future they may become the main refinery pump. An advantage of a reciprocating pump for processing is the fact that it can be used for many different services and capacities, whereas a centrifugal pump is somewhat limited in its flexibility and is usually purchased for a particular service; however, most plant operators feel that a centrifugal is the best pump, provided it is properly installed and is used for its own service.

The performance of a centrifugal pump is described by its "characteristic curves", examples of which are given in Fig. 58, which shows the performance of a centrifugal pump when handling water, gasoline, light crude oil, and a cold residuum. Three kinds of curves are shown:

1. *Head-Capacity Curves* (2). These curves slope downward to the right starting at a closed discharge head of 168 feet.
2. *Power Curves* (3).
3. *Efficiency Curves* (3). Near the bottom.

These curves tell most of the important things about the performance of the pump. A comparison of the curves shows that a centrifugal pump is not suited for handling viscous materials. When pumping viscous materials the power input is high, the efficiency is low, and the head (or pressure) changes rapidly as the capacity is changed. In addition to these inadequacies, the priming of the pump with a viscous material may be difficult or impossible.

The fluid enters the pump at the center and is thrown outward in a circular motion by the impeller. Thus, the liquid leaves the tip of the impeller at almost the speed of the impeller and the velocity that it attains at the impeller tip governs the pressure or head that is created. The kinetic energy of motion that is attained by the fluid amounts to $1/2mv^2$. Thus, the kinetic energy is dependent on the velocity, and the velocity depends directly on the diameter of the impeller and the speed at which it rotates. In practical terms, the head varies as the square of the impeller diameter and as the square of the speed.

The effect of changing the impeller diameter or the speed may be summarized as follows:

Impeller Diameter

1. The capacity varies directly as the impeller size.
2. The head varies as the square of the impeller size.
3. The power input varies as the cube of the impeller size.

Speed

Same as for Impeller Diameter.

Although these conclusions are theoretical ones, the effect of impeller size and speed have been studied experimentally and the results check almost exactly as indicated above.

An inspection of Fig. 58 shows that if the capacity is changed, the head also changes and vice versa. For this reason the application of the above principles may involve a trial-and-error type of computation. If both the new impeller size and the new speed are given, then a trial-and-error computation is unnecessary, but if a particular head and capacity is desired and the speed and/or impeller size is allowed to change to an extent that will give the desired characteristics, a trial-and-error solution is necessary.

EXAMPLE 42. *Effect of Speed and Impeller Size.*

A centrifugal pump has the characteristics as shown for water in Fig. 58. It is desired to transfer 500 gal. of water per minute at a head of 120 feet. The impeller size is 12 in. and the speed is 1450 r.p.m.

What changes in impeller size and speed may be made?

The speed may be kept at 1450 *r.p.m. and a smaller impeller used.*

Let y be the new impeller size, h the original head, and h' the new head:

$$h' = h\frac{(1450)^2}{(1450)^2} \times \frac{y^2}{12^2} = 120 \qquad \begin{matrix} h' = 120 \\ h = \ ? \\ y = \ ? \end{matrix}$$

Also, if Q = original capacity and Q' = new capacity:

$$Q' = Q\frac{1450}{1450} \times \frac{y}{12} = 500 \qquad \begin{matrix} Q' = 500 \\ Q = \ ? \\ y = \ ? \end{matrix}$$

Using a trial-and-error solution:

Assume $y = 10$

$$Q = 500 \times \frac{12}{10} = 600$$

The h corresponding to 600 (Fig. 58) is 142:

$h = 120 \times \frac{12^2}{10^2} = 173$ (not true—should be 142). By assuming several times, the correct impeller size is found to be 11 + inches.

The speed may be changed to 1200 *r.p.m. and a larger impeller used.*

$$h' = h\frac{(1200)^2}{(1450)^2} \times \frac{y^2}{12^2} = 120$$

$$Q' = Q\frac{1200}{1450} \times \frac{y}{12} = 500$$

Assume $y = 13$

$$Q = \frac{1450}{1200} \times \frac{12}{13} \times 500 = 558$$

From Fig. 58, $-h = 148$

$$h = 120 \times \frac{12^2\ (1450)^2}{13^2\ (1200)^2} = 149 \text{ (check with above)}$$

If the computations are confusing, the theory may be clarified by taking the answer, that is 13 in. and 1200 r.p.m. and correcting the points 558 and 149 to the original conditions, thus:

*Professor of Petroleum Refining, University of Tulsa.

$$149 \times \frac{13^2}{12^2} \times \frac{1200^2}{1450^2} = 120$$

and

$$558 \times \frac{13}{12} \times \frac{1200}{1450} = 500$$

The characteristics of a pump are greatly affected by the design of the impeller, the number of stages or impellers arranged in series, and the properties of the fluid. Little can be said about the design of the impeller, etc., but the effect of the fluid properties such as specific gravity, viscosity, and vapor-pressure can be foretold.

The head that is produced, when expressed as feet of fluid, is not affected by a change in the specific gravity, but if the head is expressed as lb. per sq. in., the pressure is directly proportional to the specific gravity. Thus, if a pump produces a head of 100 ft. when pumping water, it will produce a head of 100 ft. of gasoline (sp. gr. 0.7) but the pressure will drop from 43 lb. in the case of water to 30 lb. with the gasoline.

The effect of vapor-pressure is more involved and no direct methods for determining its effect have been outlined, however, the behavior of a new fluid can be estimated with fair accuracy by an examination of the vapor-pressure curve of the material and the head-capacity curve for water. Fig. 59 shows the suction lifts that can be expected with the several types of pumps and also the theoretical lift (or vapor-pressure curve) for water. Theoretically, the pump should be able to take suction from a distance below the pump that is equal to atmospheric pressure minus the vapor-pressure of the material, but in practice such lifts cannot be attained (see Fig. 59). The following tabulation indicates the effect of vapor-pressure on the head-capacity curves for a particular pump:

	Capacity drops rapidly at about
Gasoline - - - - - -	200 Gal. per min.
Light Crude Oil - - -	450
Heavy Crude Oil - - -	600
Warm Residuum - - -	650
Water - - - - - - -	700

The lowering of the head-capacity curve as indicated by this tabulation is due mainly to the vapor-pressure but it may be due in part to the viscosity.

Viscosity affects the characteristics in much the same way as vapor-pressure. A high viscosity lowers the capacity of the pump and at the same time more power is required and the efficiency is low; however, if the viscosity does not exceed about 500 seconds Saybolt at the operating temperature, little difference is noted.

The main difficulty with centrifugal pumps is that design engineers persist in placing them so that a suction lift is necessary. The pump will produce a certain lift but not until it is running. Thus, when the pump is started, or when it is stopped during operation, or if vapor-lock occurs, it must be "primed" or filled with fluid, including the suction line, before it will again function; however, if a flooded suction is provided, the pump can be vented from the top of the case and it can be easily started.

COMPARISON OF THE USES OF PUMPS

Although the particular services and the usefulness of the different kinds of pumps have been suggested heretofore, it will be useful to compare the various pumps with regard to the duties that they must perform. The following tabulated matter indicates the service features of the three main kinds of pumps:

(1) *Head and Capacity.*

Reciprocating Pumps—High head, low capacity.

Centrifugal Pumps—Low head, high capacity.

Rotary pumps are best suited for an intermediate capacity and are seldom used at heads of more than 150 lb. per sq. in.

(2) *Cost.*

The centrifugal pump, except at low capacities, is usually the cheapest; however, the cost of operating a steam pump is usually low and particularly for low capacities, high pressures or when pumping viscous fluids. Reciprocating pumps wear out and frequent repairs are necessary if abrasive-laden fluids are pumped or if the speed is high.

Centrifugal and rotary pumps also wear out but the replacements are usually less expensive. Plunger type reciprocating pumps are cheapest for dirty or abrasive-laden fluids.

(3) *Type of Fluid.*

Centrifugal pumps are best fitted for non-viscous fluids, such as gasoline, light oils, and water provided the vapor-pressure is not high.

Reciprocating pumps may be used for the same fluids as a centrifugal pump, but they can also be used for viscous materials.

Rotary pumps are suited for handling greases, oils, tars, asphalt, soap, glue, and food products but the fluids should be ones that lubricate the surfaces.

Both rotary and plunger type pumps are not suited for pumping gritty materials but they are used for this purpose to some extent because replacements are relatively less costly.

(4) *Operating Facility.*

Reciprocating pumps can be regulated to give a wide range of capacity and head by adjusting the steam valve. The same applies to rotary pumps except that expensive speed-reducing gears must be used and the range of capacity is not great.

Reciprocating pumps can maintain a constant discharge pressure through a wide range of capacity whereas the head of a centrifugal pump changes each time the capacity is changed.

Plant workmen are usually familiar with the operation and repair of reciprocating pumps but they know little about the other types; however, they are rapidly gaining a knowledge of centrifugal pumps.

The head capacity relation of a centrifugal pump is fixed

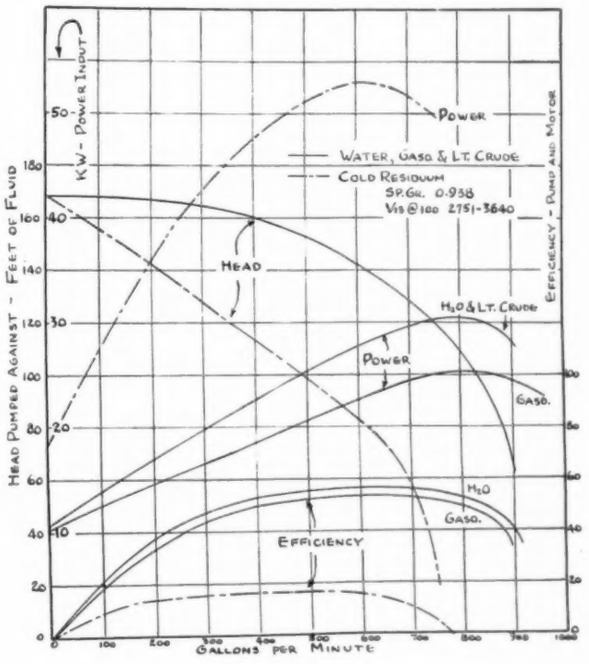
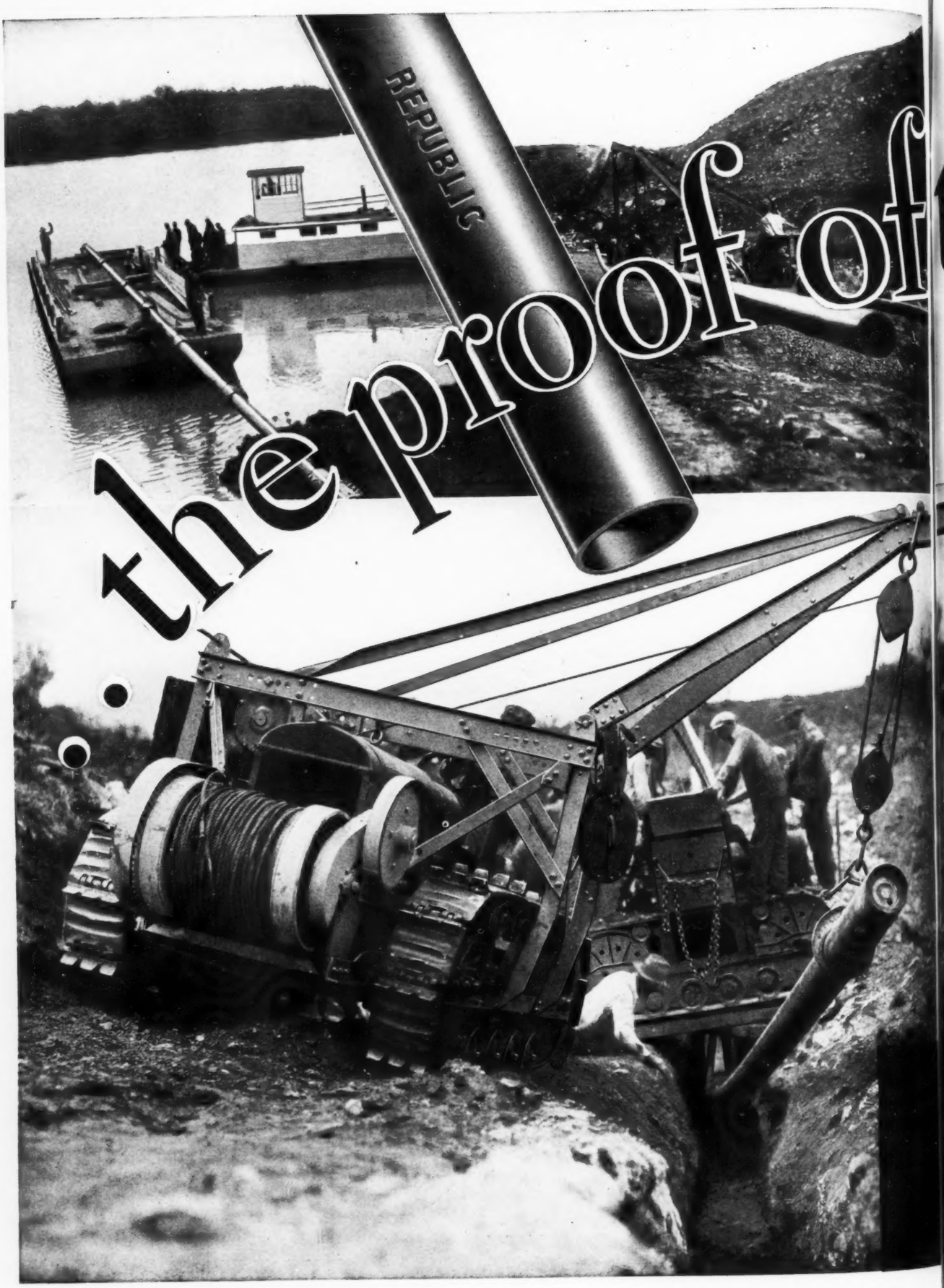


Fig. 58. "Characteristic" curves of centrifugal pumps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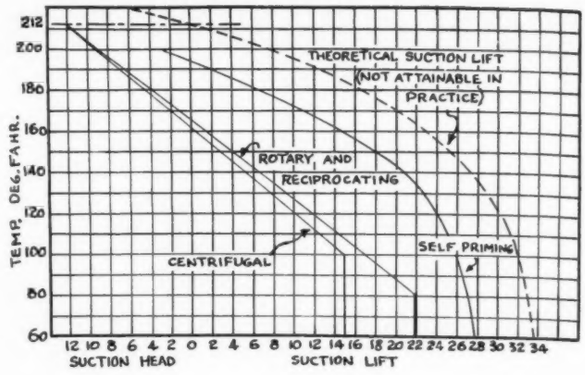

Fig. 59. Curve showing the suction lift that can be expected with various types of pumps

and it cannot be changed except by changing the speed or the impeller size. Even with these alternates the range of capacity of the pump is limited.

Centrifugal pumps must be primed each time they are started unless a flooded suction is provided, whereas positive action pumps will start even with a suction lift.

(5) *Solids in Suspension.*

Centrifugal pumps have no valves and hence they are suited for pumping fluids that contain suspended matter. The impeller, etc., do wear, but the parts can be easily and cheaply replaced.

Abrasive material ruins rotary and reciprocating pumps; nevertheless, they are widely used, particularly the plunger type, and the service is usually satisfactory if they are kept in good repair.

(6) *Suction.*

Most pumps cannot operate at a suction lift exceeding 25 feet.

The centrifugal pump gives the most trouble and many engineers feel that a flooded suction always should be provided. In case a suction lift is unavoidable, a check valve may be placed in the suction line, or an elevated tank may be provided that is filled with fluid by the pump while it is operating.

(7) *Flow*

Reciprocating and rotary pumps are positive displacement pumps. The liquid contained in them must be discharged or the pump will stop.

Reciprocating pumps give a pulsating flow. This pulsation may cause severe stresses, and vibrations that may break connections, cause fatigue in the metal of the lines and ruin delicate control instruments.

The flow from a centrifugal pump is smooth and the discharge line may be closed without serious damage.

(8) *Corrosion.*

Centrifugal pumps can be constructed of a wide range of corrosion-resistant materials including glass and stoneware, because of their simplicity, particularly the fact that most of the parts can be cast and there are few close-fitting surfaces.

Rotary pumps are also simple in design, but they have wearing surfaces that promote corrosion.

Reciprocating pumps suffer badly by corrosion because of the many surfaces that rub together. The difficulty is met by lining the cylinders with corrosion-resistant liners and by replacing the liners and rods at frequent intervals.

[EDITOR'S NOTE: This article concludes the series on Elements of Applied Petroleum Refining.]

QUESTIONS

1. Name the three characteristic curves of a centrifugal pump.
2. Tell how the performance of a pump varies with the impeller size and the speed.
3. Explain how specific gravity, vapor-pressure, and viscosity affect the performance of a pump.
4. Discuss the service characteristics of the three kinds of pumps by giving the main difference in the three types for each of the eight comparisons given at the end of the article.

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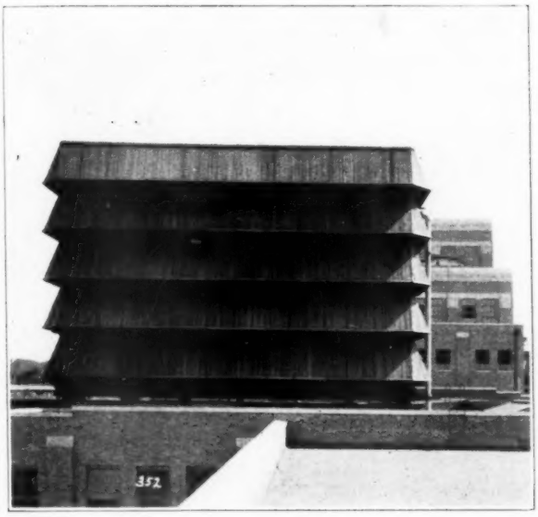
New Regulation of Tariff Protection for Refineries

In accordance with the Belgian mineral oil policy, an alteration of the provisions of the protective tariff has occurred, says a report from the U. S. Department of Interior. The difference between the import duty and the internal revenue tax, which has amounted to 30 francs per hectoliter for gasoline and 20 francs per hectoliter for kerosene, is reduced uniformly to 7.50 francs. The excise on gasoline produced in Belgium had been raised to 130 francs and on kerosene to 105 francs, while the tariff rates remained unchanged.

The tariff protection, which the government regards as adequate for economic operation of the Belgian refineries, is granted to all refiners without regard to when their plants began operations. The previous regulation provided that only refineries whose plants were in operation in November, 1934, could claim the benefits of protection, and even this only within a total quota of 50,000,000 liters. This limitation has now been removed, with the proviso, however, that the Belgian Cabinet is empowered to reduce further the protection of 7.50 francs when the output of the refineries should exceed 200,000,000 liters. To permit the refineries to adapt themselves to the new legislation, a transition period of two years is provided, while the previous protection is to be reduced by degrees and the quota limit of 50,000,000 liters extended gradually.

The aim of the new regulation is manifestly to furnish all existing refineries a possibility of existence without, however, offering any inducement to extend the existing refining capacity. Therefore, state protection has been limited to the minimum which, in the opinion of the government, suffices to attain that aim.

Equalized Water Distribution



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Look on Page 176 of your 1936 **COMPOSITE CATALOG**

See for yourself how the side openings direct the cement in an upward whirling spiral! Note also the buoyant bakelite ball which double-seals against rubber at the slightest reversal of pressure. And don't overlook the internal construction of concrete and bakelite which drill *out*, drill *up* and circulate *out of the hole*. No dangerous metal ever is used!

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LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

Modern

A commercial traveler having missed the bus found himself with two hours to spend in Brushville. He approached an ancient porter.

Traveling Man: Got a picture show here?

Porter: No.

Traveling Man: A poolroom or library?

Porter: No.

Traveling Man: Well, how on earth do you amuse yourselves?

Porter: We goes down to the grocery store in the evenings. They's got a new bacon slicer.

✦ ✦ ✦

The novice at fishing had hooked a very small trout on a little lake in the Canadian wilds. He wound it in excitedly until it was rammed against the end of his rod. Then he turned inquiringly to the guide and said: "What do I do now?"

"Climb up the rod and stab it with your hunting knife," the guide drawled.

✦ ✦ ✦

"We've got to give him something that'll backfire on his nose and make him sneeze," said the veterinarian, called upon to treat the lumberjack. "Mix up a pint of linseed oil, a half cup of salt, a pint of castor oil and some red pepper. Let me know in the mornin' how he feels."

The next morning the foreman called the house doctor on the phone.

"Lars sneezed last night," he reported.

"That's fine," replied the doctor. "How many times?"

"Three," shot back the foreman, "Once before and twice after he died."

✦ ✦ ✦

A farmer had hired a new assistant, who knew absolutely nothing about farm life.

"Come here," he said. "I'll show you how to milk a cow."

"Don't you think, sir," replied the new one, "that I had better start on a calf?"

✦ ✦ ✦

Frosh (bumping into grey-haired man on campus): Say, where d'ya think you're going?

Man: Listen, I guess you don't know who I am. I'm the assistant football coach.

Frosh: Pardon me, I thought you were the Dean.—*Minn. Ski-U-Mah.*

"Oh, Fred, the baby has swallowed the matches. What shall we do?"

"Here, use my cigarette lighter."

—*Annapolis Log.*

✦ ✦ ✦

"Is this the laundry? Well, you sent me a half a dozen very old handkerchiefs instead of my shirt."

"Them ain't handkerchiefs. That is your shirt."

✦ ✦ ✦

Mother: George, dear, you know Joan is seventeen years old now and I just had a long talk with her about the facts of life.

Father: Ah, good. And did you learn anything new?

✦ ✦ ✦

"Is Mary the home-loving type of girl?"

"Naw, ya gotta have a roadster."

—*Ohio Sundial.*

✦ ✦ ✦

Last Request

His wife lay on her death bed. She pleaded: "John, I want you to make me one promise. Will you ride in the same car with mother to my funeral?"

He sighed. "O.K., but it's going to spoil my whole day!"—*Ohio Sundial.*

✦ ✦ ✦

"I am sorry," said the dentist, "but you cannot have an appointment with me this afternoon. I have eighteen cavities to fill."—And he picked up his golf bag and went out.

—*Notre Dame Juggler.*

✦ ✦ ✦

Scotch Gent: My lad, are you to be my caddie?

Caddie: Yes, sir.

Scotch: And how are you at finding lost balls?

Caddie: Very good, sir.

S. Gent: Well, look around and find one so we can start the game.

✦ ✦ ✦

Bird in Tree: Here comes that farmer who chased us out of his garden yesterday. I wonder if he will recognize us?

Second Bird: I don't know. I will see if I can catch his eye.

✦ ✦ ✦

"Will you marry me in spite of my trouble?"

"What is it?"

"Falling hair."

"You darling boy. To how much?"

—*Stanford Chaparral.*

A colored preacher having read his flock several verses from the Bible concerning virgins, requested all the virgins in the congregation to come up on the platform. Among the last came a young woman who was stopped by the parson.

"Hol' on dere, sister. How come you come up here with dat baby? You ain't no virgin."

"Oh, yes, I is, preacher. I'se one of dem foolish virgins."

✦ ✦ ✦

A recruit wearing size fourteen shoes enlisted in the army. One day his officer missed him.

Officer: Has anyone seen that raw recruit?

Voice from Rear Rank: Yes, sir. He's gone down to the cross-road to turn around.

✦ ✦ ✦

Guide: This castle has stood for 600 years. Not a stone has been touched, nothing altered, nothing replaced.

Visitor: Um, they must have the same landlord we have.

—*The Bee-Hive.*

✦ ✦ ✦

"Rastus," said the judge sternly, "you are found guilty of having stolen two chickens from Mr. Wilkerson's coop last week. Your fine will be $5.00."

"Yessuh, jedge, y'honor," said Ratsus, laying a $10.00 bill on the clerk's desk.

"Here's ten bucks that'll pay yuh up to an' includin' nex' Sattidy night."

✦ ✦ ✦

Three blood transfusions were necessary to save the life of a lady patient in the hospital. A brawny young Scotchman offered his blood. The patient gave him $50 for the first pint, $25 for the second pint—but by the third time she had so much Scotch blood in her she only thanked him.

✦ ✦ ✦

"I can't marry him, mother; he's an atheist, and doesn't believe there is a hell."

"Marry him, my dear, and between us we'll convince him he's wrong.

✦ ✦ ✦

First Burglar: Come on, let's total up and see how much we made on this haul.

Second Burglar: Naw, I'm tired. Let's wait and look it up in the morning papers."

J. C. GORDON, petroleum engineer, has been transferred from the staff of the Lago Petroleum Corporation at Maracaibo, Venezuela, to that of the Standard Oil Company of Venezuela at Caripito.

A. W. G. BLEEK and **DEREK FITZGERALD** recently were appointed directors of the British Burmah Petroleum Company, Ltd. **R. H. TRENCH** has resigned from the board.

CHRISTOPHER DALLEY, director of the British Controlled Oilfields, has returned to his London, England, headquarters following an inspection of the company's properties in Venezuela and Trinidad.

BLAINE JOHNSTON, at one time general superintendent for the Simms Oil Company, but recently associated with Warren L. Todd, Inc., Dallas, Texas, has been made a vice-president of the latter organization. At present, Johnston has his office at Hobbs, New Mexico.

D. R. SNOW, vice-president in charge of production and geology for the Barnsdall Corporation, has been made a director of the company to succeed George D. Locke.

VAN D. BENNETT, assistant superintendent of production for the Derby Oil Company, Wichita, Kansas, has resigned to become a production engineer with the British American Oil Production Company, Tulsa, Oklahoma. Bennett long has been active in affairs of the American Petroleum Institute. At present he is vice-chairman of the Kansas Chapter, secretary-treasurer of the Mid-Continent Section, and a member of the national committee on pump standardization.

BILL WISDOM, farm boss for the Pure Oil Company in the Van field of Texas, has been made superintendent of the Carroll district, which is a part of the Van field. **C. O. DENNING,** who has been superintendent of the Carroll district, has been made drilling superintendent of the Van field.

J. A. KELLEY, engineer with the Stanolind Oil and Gas Company at High Island, Texas, has been transferred to the Hastings area, also in South Texas.

MARK MATHESON, independent operator of Muskogee, Oklahoma, has moved to Midland, Texas, and will operate in the West Texas-New Mexico Permian Basin area.

WILLIAM JOHNSON, supervising driller of the U. S. Geological Survey, with headquarters at Casper, Wyoming, is now in California, where he will remain for several months.

THOMAS PREBODA, foreman for the Barnsdall Oil Corporation at Bakersfield, California, has been transferred to Rosecrans.

F. A. LEOVY, of Pittsburgh, Pennsylvania, vice-president in charge of production for the Gulf Oil Corporation, and **K. C. HEALD,** chief geologist, also of Pittsburgh, recently made a tour of the company's properties in the Mid-Continent area.

E. H. MOORE, president of E. H. Moore, Inc., one of the large operators in the Fitts Pool of Oklahoma, is taking a vacation trip through South America, accompanied by Mrs. Moore.

W. C. ROBERTSON, chief clerk for the Humble Oil and Refining Company in the Pyote district of Texas, is now making his headquarters in Ector County, having been transferred to that district.

RAY C. WILLIAMSON, production foreman for the Pure Oil Company in the Van field of Texas, temporarily is at Mount Enterprise, Michigan, where he is supervising the drilling of a deep test.

CLYDE CANTRELL, Mount Pleasant, Michigan, has been elected president of the newly-organized Cryden Oil Company. **ALLEN GRAY,** Pontiac, Michigan, is vice-president; **HASWELL W. GRANT,** Mount Pleasant, secretary; and **RAYMOND S. HUNT,** geologist.

VIRGIL M. VOORHEES, who has been a drilling contractor and producer in Michigan fields for a number of years, has become associated with the Midland Petrol and Gas Company of Detroit, Michigan.

W. J. BROWN, tool pusher for the Humble Oil and Refining Company in the Anahuac field of Texas, has been promoted to superintendent of the West Beaumont district.

RAY E. KOLLAR, who resigned recently as superintendent for the Carter Oil Company in the South Burbank field of Oklahoma, is now in Texas with the Salt Dome Oil Company.

WILLIAM A. KRAUS has been appointed proration engineer by the Phillips Petroleum Company, Bartlesville, Oklahoma. During the last five years he has been doing independent consulting work, specializing in proration engineering in the Mid-Continent area, and in the technical phases of oil and gas litigation.

JOSEPH HUGHES has been placed in charge of the Swanson Oil Company's new office at Alma, Michigan. The company, of which A. E. Swanson is the head, are operators in the Crystal Township field, Montcalm County.

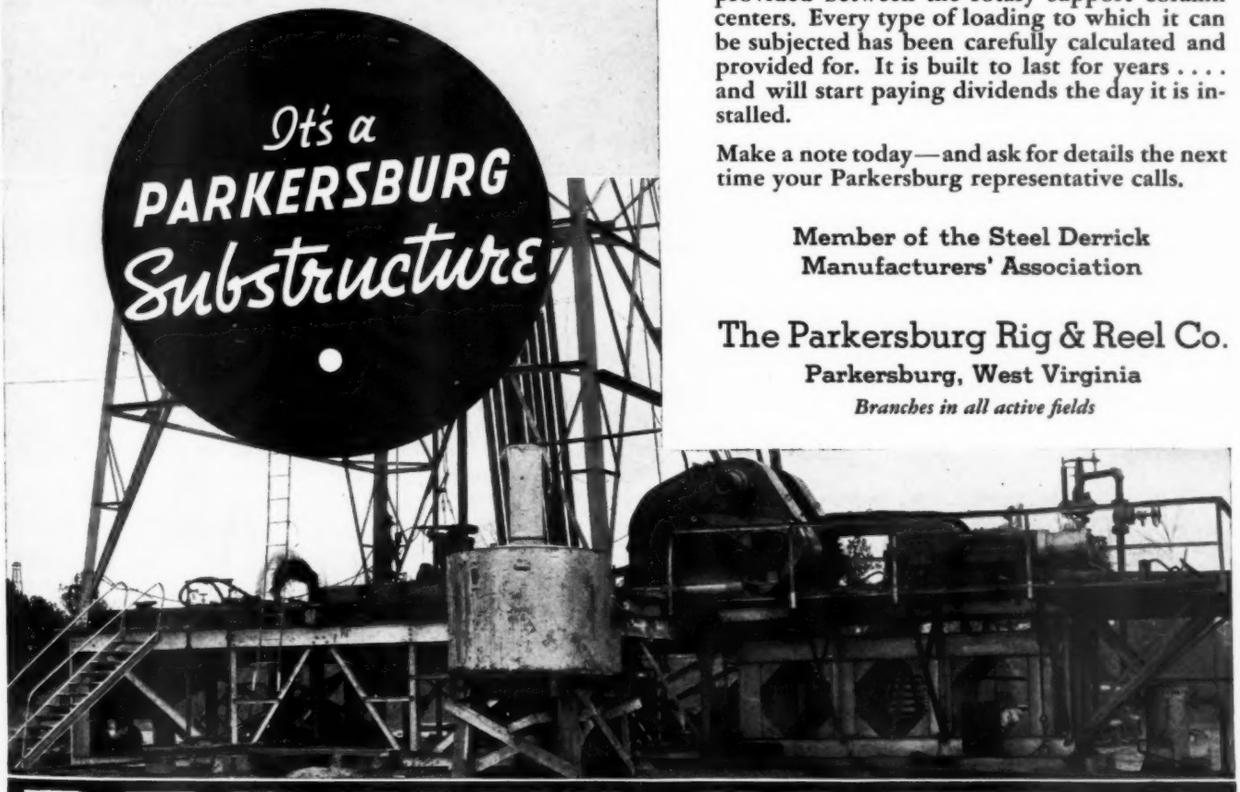
S. B. ROBERTS of Albany, Texas, **J. C. HUNTER** and **R. C. GRAHAM** of Abilene, Texas, have formed the S. B. Roberts Company, drilling contractors. Headquarters are in Abilene.

HENRY MILLER of Blackwell, Oklahoma, has been promoted to the position of superintendent of production for the Lario Oil and Gas Company, and is making his headquarters at Galva, Kansas. H. D. Broadwater has been made drilling superintendent.

BEN E. LINDSLY, petroleum engineer with the United States Bureau of Mines, with headquarters in Washington, D.C., recently spent some time in the East Texas field gathering data on reservoir pressure.

This cellar was "dug" with a wrench

--and can be moved to the next location. It will be in use for years to come!



● Obviously, it is impossible to dig a cellar with a wrench. The statement does serve though to illustrate the vast difference between the old style cellars with their expensive, non-salvable wood and concrete construction, and the new improved Parkersburg Steel Substructure.

Steel substructures were pioneered and brought to their highest state of perfection by Parkersburg. Designed originally for use over water or marshes, their time and money saving features have warranted their adoption in fields all over the world. Easily erected, portable, 100% salvable, they meet every requirement for safety and economy.

Drilling crews in particular appreciate the advantages of having the blowout preventer or master gate valve above ground. It is readily accessible from four sides, and eliminates many of the dangers and inconveniences of the conventional type cellar.

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Engineers Seek Yardstick for Boys Most Likely to Succeed

IF A BOY is proficient in mathematics in high or preparatory school is he likely to make a success of an engineering course in college? Suppose he is a good speller, or has a good vocabulary, or can write a good letter or report, do those accomplishments have any bearing on the question of whether or not he should take up engineering? These are some of the things that the Committee on Student Selection and Guidance, of the Engineers' Council for Professional Development, is working out.

Preliminary results indicate that the answer to the first question is "yes", which is not entirely surprising. A year ago eight well-known engineering schools, at the committee's request, gave to their incoming freshmen the cooperative test in mathematics as developed by the American Council on Education. At the end of the year the rating of each student in this test was compared with his general scholastic average for the year, and a so-called correlation determined. If this coefficient were as high as 1 it would mean that the test was a perfect indication of what the student would accomplish during the year; if the coefficient were 0 it would mean that the test had no bearing whatever on what he would do in his first year at an engineering college. The general average for 1767 students turned out to be 0.55, indicating that the mathematics test was an excellent indication of freshman accomplishments. Other tests have shown that the correlation between the first year and the other three years of a four-year course is high. If a freshman fails in but one subject he has a good chance to graduate in the regulation four years, but if he has more than one failure his chance is slim without summer school, tutoring, or correspondence courses.

Entering freshmen at the same eight engineering colleges also were given a special test in English, which was in three parts covering spelling, vocabulary, and usage. The resulting correlation between the English test score and the first year average for all subjects in the engineering curriculum was about 0.40, or lower than for the mathematics test, but still indicative that a student proficient in the various branches of English is adaptable to engineering work. A less comprehensive study at one engineering college alone, showed that usage ranked far above vocabulary and spelling as an indicator of engineering aptitude. That is, one may be a poor speller and still be likely to succeed as an engineering student, but ability in the use of English is about as necessary as to be proficient in mathematics. In other words, an engineer must be able to organize and express his thoughts in clear, concise English.

The committee directed similar work at a larger number of engineering schools in September of this year, and the correlations begun last year will be continued throughout the entire engineering course. Other tests of engineering aptitude also are being developed. It has been found that ability in descriptive geometry is an especially good criterion of the probable success of a student in engineering curricula, and it is hoped that a test can be devised for potential engineering students that will measure the same quality of imagination that descriptive geometry does. At present, there is no thought that these tests will be used to exclude students from engineering schools, but the committee is seeking tests that will aid in selecting better students and in assuring them that they have interests and aptitudes that are likely to assure their success in the engineering field. Dean R. L. Sackett, of the School of Engineering at the Pennsylvania State College, as chairman of the committee, is directing the work.

Another important phase of the committee's activities is the organization of guidance programs and procedures for the aid of preparatory-school students. Many of the local branches of the national engineering societies that are sponsoring the Engineers' Council for Professional Development have appointed committees to address high-school groups and to confer with individual students about interests, aptitudes, curricula, and fields of work. Professional engineers are especially active in this work in Milwaukee, Birmingham, Schenectady, Cleveland, Detroit, Atlanta, Kansas City, Sacramento, Baltimore, St. Louis, Providence, Philadelphia, and Washington. These engineers supplement the work of the vocational advisers at many schools. Wide distribution of a pamphlet "Engineering: a Career—A Culture" has been a valuable aid. This may be obtained for 15 cents from Engineers' Council for Professional Development, 29 West 39th Street, New York, N. Y.

Though only one of the four major activities of the Engineers' Council for Professional Development, student selection and guidance is fundamentally the most important for it seeks to awaken an interest in engineering by those young men—and an occasional girl as well—that are likely to achieve the highest success in the engineering field. If only the right men are encouraged to enter engineering schools a long step will have been taken towards increasing the recognition accorded to the profession.

A.P.I. Booklet Reviews Broad Scope of Activities

"The Story of the Institute" has been published by the American Petroleum Institute as a 32-page printed record of services being rendered by the petroleum trade association to its members and to the industry.

The text is by W. R. Boyd, Jr., the Institute's executive vice-president, who explains in the foreword that the book has been published in "the hope that every oil man reading it will have a more complete understanding of the Institute's work."

Chapters are given over to organization, activities, and membership; to the work of the divisions of production, refining, and marketing; to the departments of statistics, accident prevention, engineering, and public relations, and to committee work, coöperative activities, and publications.

A.P.I. Publishes Oil Production-Drilling Chart

"Petroleum Drilling and Production" has been published by the American Petroleum Institute as a chart showing details of commonly-used methods of drilling for and producing crude oil. The chart, which is 17 in. by 22 in., is a companion to the "Petroleum Flow Chart" published two years ago as a simplified explanation of complicated refining processes.

The new chart shows cable tool and rotary drilling rigs in detail, with essential parts named, cross sections of typical formations in which oil is found, and methods of production and equipment used both in flowing and pumping wells. It also presents pertinent production data of general interest.

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SEE PAGE 1279 • 1936 COMPOSITE CATALOG FOR FULL DETAILS

Gasoline engine driven McNEELY Vibrating Mud Screen on "Island" pier, Rincon Field, Ventura County, California.

EVERY dollar you invest in a McNEELY Vibrating Mud Screen returns big dividends. This unit saves time; helps prevent damage to pump, valve and swivel parts; protects against stuck drill pipe and caving hole. The absolutely tight screen cloth cannot whip or flex – and consequently often gives from 10 to 12 weeks continuous service. These advantages all mean savings!

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BID THE Buckeye WAY • ask for our operation data before you bid

We invite you to our booth No. 3, Pennsylvania Avenue, during the Tulsa Petroleum Exposition

TRADE LITERATURE

PROPERTIES OF TONCAN IRON is the title of a 12-page folder issued by the Republic Steel Corporation, Central Alloy Division, Massillon, Ohio, which contains a large fund of condensed up-to-date information on rust-resisting Toncan Copper Molybdenum Iron. Two particularly important sections give complete physical properties and physical constants of this corrosion-resisting alloy iron. Copies will be supplied upon request to the Advertising Department, Massillon, Ohio.

THE A. O. SMITH CORPORATION, Milwaukee, Wisconsin, has issued Bulletin 526 descriptive of its High Yield Casing. The bulletin is profusely illustrated with charts, drawings, and photographs and will be sent free to all interested parties upon request.

AN ENGINEERING LEAFLET 2218 on the Allis-Chalmers recently announced "Ro-Twin" compressor is now available. It describes in detail and illustrates this innovation in rotary compressor design, giving specifications, table of capacities, and approximate dimensions. Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, will mail one of the leaflets upon request.

BLACK, SIVALLS AND BRYSON, INC., Oklahoma City, Oklahoma, have issued a "condensed catalog" describing and showing in illustration its line of oil industry equipment, including tanks, separators, gas scrubbers, valves, pipe, pressure vessels, fittings, etc.

THE OIL WELL SUPPLY COMPANY, Dallas, Texas, has issued the following bulletins:

Bulletin No. 117 on the "Superior Sand Pump."

Bulletin No. 131 on the "26-in. Make-and-Break Rotary, Model 34."

Bulletin No. 139 on "Silverline Seamless Steel Working Barrels."

Bulletin No. 150 on "Drill Collars."

Bulletin No. 152, descriptive of the "Oilwell No. 300 Crown Block."

Bulletin No. 144 on the "No. 100 and No. 150-A Oilbath Rotary Swivels."

Bulletin No. 146 on "No. 7 Vertical Twin-Cylinder Steam Engine."

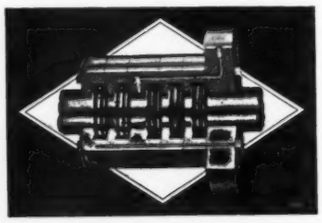
All publications are fully illustrated and are available free upon request.

A NEW CATALOG, No. 1520, 40 pages, 6-in. x 9-in. page size, beautifully illustrated, has been published by Link-Belt Company, Chicago, Philadelphia, San Francisco, on Link-Belt anti-friction bearing units available in streamlined pillow block, hanger, take-up, flanged, duplex and special mountings. The book is said to be the first covering the complete Link-Belt anti-friction bearing line. A copy will be sent to any reader upon request, which may be addressed to the company's nearest office.

THE CUMMINS DIESEL Engine Company, Columbus, Indiana, manufacturers of Cummins Diesel engines, has issued a new booklet, "Read the Record," in which is portrayed numerous typical installations of the Cummins Diesels. The material is divided into three groups: "Trucks and Busses," "Industry," and "Marine Field."

More Evidence That

COOK'S METALLIC PACKINGS . .



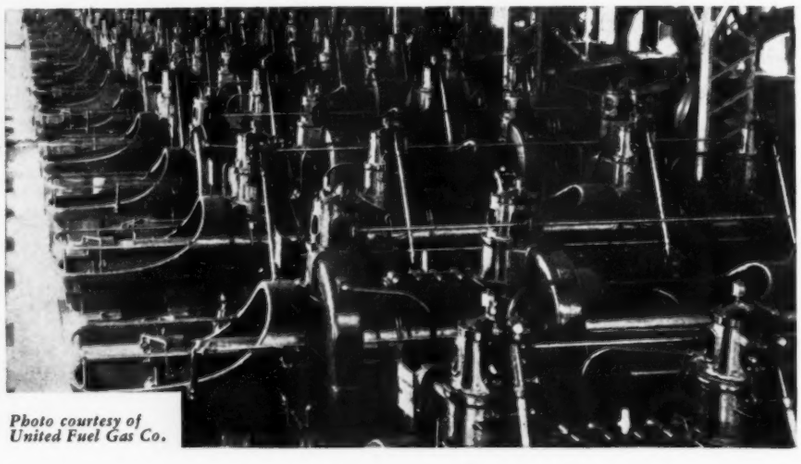


Photo courtesy of United Fuel Gas Co.

. . predominate *in the* NATURAL GAS INDUSTRY

Wherever you may look throughout the oil and gas fields you will find COOK'S Metallic Packing predominating on the power and compression rods of gas pumping and gasoline extraction engines. A noteworthy example is furnished by the Cooper-Bessemer engines shown, which are operated by the United Fuel Gas Company in West Virginia.

BOOTH 51 TEXAS BUILDING

WRITE for INFORMATIVE LITERATURE on PACKINGS

C. LEE COOK MANUFACTURING CO.

INCORPORATED

LOUISVILLE, KY.

New York Cleveland Baltimore Los Angeles Chicago Tulsa New Orleans San Francisco

A BOOKLET ON THE IMPROVED FABRICATION of 18-8 chromium steels, has been published by The Linde Air Products Company, 30 East 42nd Street, New York City, an eight-page, illustrated discussion of improvements in technique and materials. It is available free of charge upon request.

GAS POWER, INC., Esperson Building, Houston, Texas, is issuing a chart for the quick calculation from the observed information at hand of the weight of a column of gas in a well. This chart will be sent free to petroleum engineers or other experimenters who write to the company.

THE LINDE AIR PRODUCTS COMPANY, 30 East 42nd Street, New York, has available a booklet, "How to Bronze-Weld," summarizing the available information on bronze-welding and bronze-surfacing. This is a practical presentation of the fundamental theory and technique of bronze-welding and bronze-surfacing.

One of the questions considered is the important one of choosing the correct welding rod. The all-purpose bronze welding rod containing certain definite proportions of silicon is recommended for most purposes on account of its excellent welding properties, weld strength, ductility, soundness, and machinability. It is particularly suitable for building up wearing surfaces. An outline of the development of this rod is given.

The step-by-step general procedure for bronze-welding and bronze-surfacing is given, as well as special information and advice. Other topics covered are preheating considerations; the bronze-welding of cast iron, malleable iron, carbon steels, alloys, wrought iron, galvanized iron and steel, sheet metal, copper, brass and bronze, nickel and Monel metal; and the joining of dissimilar metals. The procedure to be used in each case is described.

* * *

DIRECT CURRENT TURBINE-generator sets of from 10 to 400 kw. are described, and their operating advantages enumerated, in a new four-page folder, Bulletin GEA-2295, published by the General Electric Company, Schenectady, New York.

* * *

Pittsburgh Equitable Meter Company Operations Not Affected by Flood

The recent flood waters that descended upon Western Pennslyvania, inundating a large portion of the business section of Pittsburgh and demoralizing manufacturing activities for many firms, caused but slight inconvenience at the plant of the Pittsburgh Equitable Meter Company.

The factories, situated in the high eastern residential section of the city were not touched by flood waters. Only short shut-down was made necessary while emergency equipment was obtained to supply power. It was announced that all orders on the books would be shipped without delay and that stock shipments of basic products and parts could be made on short notice to those utilities whose operations had been affected by the high waters.

During the height of the flood, the company gave 24-hour service to utilities in the stricken area and aided materially in bringing about the early resumption of normal service, while many employees served with Red Cross for the duration of the emergency.

LONG SERVICE ASSURED!

Every FLUPACO Seat and Ball Must Pass This Rigid Hardness Test

The tolerance of plus or minus one point of the required hardness set for FLUPACO seats and balls is rigidly maintained by testing every seat with the Rockwell Hardness Tester.

The fine fissures which develop in a seat that is brittle open up under pressure and allow sand to cut the seat away. A seat that is too soft is doomed to quick failure. Years of experience and careful research have taught us the right degree of hardness that insures a minimum of down time for the pump equipped with FLUPACO seats and balls.

Equip Your Pumps With FLUPACO Seats and Balls

They are made in both the Ring Type and Flat Type for all types of pumps. Order a supply today.

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A MODERN PUMP FOR MODERN CONDITIONS

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"Glorified Machinery" Theme of International Petroleum Exposition

"Glorified Machinery" is the theme of the Ninth International Petroleum Exposition to be held in Tulsa, May 16 to 23. Evidence of better conditions in the industry is seen in the fact that 496 firms from Maine to California had purchased practically every available inch of the 180,000 sq. ft. of exhibit space ten weeks before the gates were to open.

W. A. Schleuter, chairman of the scientific and technical committee, predicted the greatest array of new developments in scientific methods of exploration, production, and refining in the history of the industry. One entire building will be devoted to exhibits sponsored by this committee. An inventors' congress will be held. A special committee has spent months considering applications from inventors of new, and in some cases, wild-eyed gadgets and devices calculated to revolutionize various phases of the industry. The most practical of these will be displayed.

The largest display of heavy machinery ever seen at the Exposition is promised. Electrical power will be used more extensively than ever before in the drilling units that will actually "make hole" on the Exposition grounds.

W. G. Skelly, Exposition president, states that fully 10,000 pieces of new equipment will be exhibited, all of it embracing developments since the last Exposition was held two years ago. The total value of all exhibits is placed at $10,000,000.

Diesel engines will be exhibited on a larger scale than ever before, including a new Diesel-powered oil field tractor with V-type, 8-cylinder, 160-hp. engine. The new line of tractors, ranging from 25 hp. to 95 hp., are equipped with winches, sidebooms or bulldozers to pull and run rods and tubing, bail and clean wells, operate drilling rigs or skid them to new locations, shunt cars, lay pipe, ditch, build slush pits and fire lines, etc.

Exhibitors will show improvements in valve and fitting construction, new pumping units, improved pumping well hook-up equipment, and improved sucker rod handling apparatus.

In fact every new scientific and mechanical development of the past two years pertaining to the oil industry will be on view.

Holding of a number of important annual conventions of oil associations immediately preceding and during the Oil Exposition will increase this year's attendance to 200,000 oil men, or more, in the opinion of W. B. Way, general manager. Among the meetings are those of the American Petroleum Institute, the Independent Petroleum Association of America, the Natural Gasoline Manufacturers' Association, and the Institute of Petroleum Technologists of London, England.

Certain changes are announced by the Associated Oil Company as follows:

L. E. Foust, who has been superintendent of the company's Kern, Midway, McKittrick, and Lost Hills division, is assigned to special duties in the land department with headquarters in San Francisco.

All company development and producing operations in the San Joaquin Valley, California, have been consolidated under the San Joaquin division. George O. Suman is appointed superintendent of this division, with headquarters at Coalinga.

F. M. Watkins is appointed assistant superintendent of the San Joaquin division, with headquarters at Coalinga.

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MARTIN-DECKER CORP.

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Mid-Continent Distributor: REED ROLLER BIT COMPANY, Houston, Texas

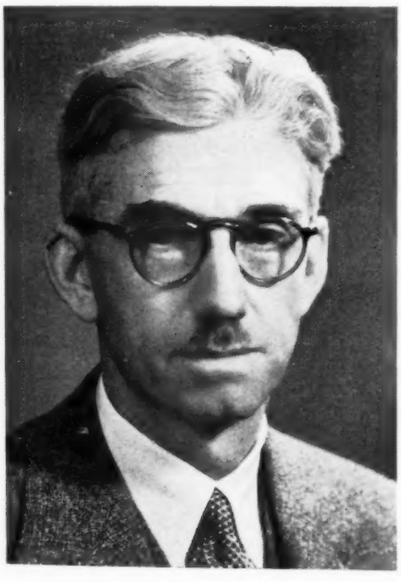
Emsco Elects Two New Directors

Stockholders of the Emsco Derrick and Equipment Company, at their recent regular meeting, elected two new directors: Ernest N. Puetz and W. D. Davidson.

Davidson succeeds the late Edwin W. Goeser. He was associated with Goeser at the National Supply Company, Torrance, California, prior to 1923, when they both left there to become associated with the Emsco Tool Company, merged with the Emsco Derrick and Equipment Company on January 1st, 1926. Davidson is chief engineer for the mechanical division, and enjoys a high reputation in his particular line of endeavor, having been in the oil industry since 1911.

ERNEST N. PUETZ

Puetz, who succeeds S. P. Farish in the office of director, also holds the office of controller, as well as assistant secretary and assistant treasurer, and has been with the Emsco Derrick and Equipment Company since 1927. Prior to his association with this company he was employed by the Blaw-Knox Company at Pittsburgh, Pennsylvania, for a period of 15 years as assistant controller and special assistant to the operating vice-president. He is a member of the Controllers' Institute of America, and has broad experience in manufacturing and administration.



W. D. DAVIDSON

E. H. Adams Makes New Connection

E. H. (Ernie) Adams, chemical engineer, well-known on the Pacific Coast, has become associated with Merco Nordstrom Valve Company and Pittsburgh Equitable Meter Company. He will make his headquarters in the Los Angeles office of these concerns.

For many years Adams has been active in the natural gas industry and has been associated with various companies in charge of production. He also is well-known in oil, chemical, and hydraulic circles. He is a member of the California Natural Gasoline Association and the California Meter Association. He is a graduate of the University of California.

In his new position Adams will devote his time to sales and engineering work in the interest of Pittsburgh Meters, Nordstrom Valves, and allied products. He will cover Southern California. H. Boezinger is manager of the Los Angeles office.

ERNIE ADAMS

K. G. Myrberg Goes with Pittsburgh Equitable

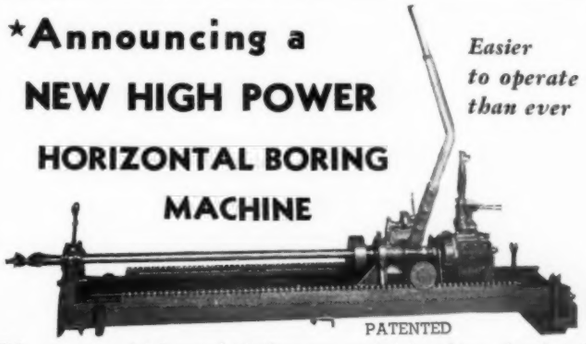
Pittsburgh Equitable Meter Company and its subsidiary, the Merco Nordstrom Valve Company, Pittsburgh, Pennsylvania, announce that K. G. Myrberg has joined its sales force.

Following several years field and executive work with two midwestern railroads, Myrberg joined the National Cast Iron Pipe Company in 1923. He has been with this company and its successor, James B. Clow & Sons, Chicago, until his recent appointment. He will operate from the Des Moines, Iowa, office of the meter and valve company under the supervision of A. L. Fritchey, district manager.

K. G. MYRBERG

***Announcing a NEW HIGH POWER HORIZONTAL BORING MACHINE**

Easier to operate than ever



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This compact, high-speed Hydrauger model has been developed from many years' experience in building horizontal boring machines. It embodies features of the larger sized Hydraugers plus other important refinements.

It is a high-power, medium priced unit for rapid boring of horizontal holes up to 14½" in diameter.

Important advantages are: greater ease of setting-up and boring; straighter boring; lowest cost and fastest installation of underground piping; and minimum investment.

Hydrauger units are indispensable when installing wrapped or coated pipes. They have been widely used to prevent pavement cutting, ditching, traffic interruption, and destruction of lawns or gardens when installing horizontal piping. Installation costs are often reduced 90%. In many instances where pavement cutting permits were refused the Hydrauger was the only possible solution. Invariably a Hydrauger will pay for itself within one year, and often on a single job.

Ask for full details of the new Hydrauger Model 2A-2X.

HYDRAUGER CORPORATION, Ltd.
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FEATURES

- *5-horsepower airmotor gives 50% faster boring.*
- *New 4' 8" boring bar sections easier to handle.*
- *Extra strong hi-tensile alloy boring bar joints.*
- *New shaped cutters both cut and undercut at the same time for faster boring.*
- *Short, rigid frame requires less ditching for setting-up.*
- *Higher speed boring insures greater accuracy.*
- *Bores holes 2½" to 14½".*

HYDRAUGER
"The Mechanical Gopher"

Tretolite Patents Upheld

U. S. Commissioner David B. Head, sitting as special master in a suit filed at Los Angeles by The Tretolite Company of California, Ltd., today held U. S. patents Nos. 1,223,659 and 1,467,831, involving processes for treating petroleum emulsions, to be valid. California Production Company, Henry Branham, and Arthur J. Dietrick were held to have infringed the latter patent by using a chemical, "Hydrate 488," for this purpose. Research Products Company, Ltd., and Abraham M. Herbsman, manufacturers of the chemical, were held to have contributed to the infringement by supplying the re-agent for the purpose of the patent. The report of the special master recommends that the Federal District Court issue an injunction "restraining the defendants from the acts found to infringe Letters Patent No. 1,467,831 and that an accounting of profits and damages be had."

Several other actions involving these same two Treolite patents are pending in this district:

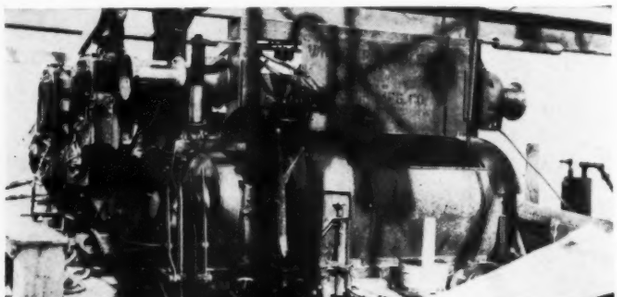
In Equity No. Y-40J, in which Dehydrators, Ltd., and Italo Petroleum Corporation of America are named as defendants, the chemical involved being known as "Nobs."

In Equity No. 54-M, Bell View Oil Syndicate, defendant.

In Equity No. 106-H, in which C. I. Keller (doing business as Superior Chemical Company) and Leo D. Dysert are defendants, and the alleged infringing material is known as "Superior."

In addition to the local suits involving these two patents, an action known as In Equity No. 945 was filed in the Eastern District of Texas, Tyler Division, on November 20, last, in which infringement of the second of these patents is charged. Defendant is the Welch-Sandler Oil Company, and the alleged infringing material is known as "Demulso."

Another suit, filed in the District of Kansas, Second Division, on November 26, last, and known as In Equity No. 935N, has been terminated by the issuance of a consent decree and permanent injunction. Defendants were Study-Turner-Lloyd-Frost associates, and the chemical involved was known as "Dehydro 705."



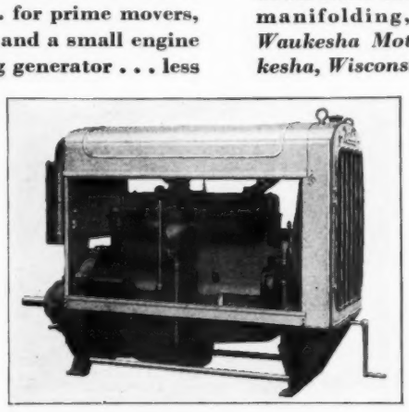
Portable GAS ENGINE RIG

Drills Shallow Wells with Low Fuel Cost

For drilling shallow tests in the Cushing, Okla., gas field, drilling contractor John Nunnelee is using a portable rig powered by two 6-cyl., 5 x 5½, gas burning DHKU Waukesha Engines. Engines operate independently . . . one for driving mud pump; other for drilling. Both may be connected to furnish power to draw works and still operate pump.

One job, bottomed at 3,090 ft., took 22 days . . . and total fuel cost was $150.84 . . . for prime movers, rig floor stoves and a small engine driving lighting generator . . . less than $7 a day, or about 5 cents per foot of hole.

The engines used by Mr. Nunnelee . . . Waukesha High-Duty Sixes . . . are built to meet the demand for a modern portable power unit in the 80-125 hp. range that will stand up under severe continuous duty in the oil fields. Their design embodies such advanced features as removable wet sleeve cylinders, built-in governor, seven main bearings, filtered pressure oiling, down draft carburetion, improved manifolding, overhead valves. *Waukesha Motor Company, Waukesha, Wisconsin.*



WRITE today for Bulletin 1019

WAUKESHA ENGINES

Second World Petroleum Congress to Be Held at Paris in June, 1937

The second World Petroleum Congress will be held at Paris, France, in June, 1937, upon the occasion of the International Exposition. The Congress will be sponsored by the Institution of Petroleum Technologists. Organization work has been placed with the French Association of Petroleum Technologists, 44 Rue de Rennes, Paris, VI, France.

The program, which will have as its objective the joint study and discussion of scientific, technical, economic, and administrative problems related to petroleum and petroleum products, will be divided into five sections: geology and drilling, physical chemistry and refining, materials and construction, technique of the utilization of liquid fuels, and economics and statistics.

Baroid Sales Company Opens Office and Laboratory at Tulsa

Baroid Sales Company announces the opening of a Mid-Continent office and laboratory at 502 Tulsa Building, Tulsa, Oklahoma. D. A. Sikes, sales manager for the Mid-Continent, is in charge. The laboratory, similar to the ones at the Los Angeles and Houston offices, is completely equipped to test drilling muds.

Hyatt Roller Bearing Inventor's Associate Passes on at 86

Charles S. Lockwood, who worked along with John Wesley Hyatt on the invention of the Hyatt Roller Bearing, died in Newark, March 20, in his eighty-sixth year.

As an active member of the Hyatt experimental laboratory staff almost up to the time of his passing, Lockwood's career covered 62 years of service in the employ of John Wesley Hyatt and the companies Hyatt founded. More than 44 of these years were devoted to the Hyatt Roller Bearing Company, since its incorporation in 1892. At a "60 years of service" testimonial dinner tendered to him by his Hyatt associates in December, 1934, it was recorded that in 1874, when a lad in his twenties, he joined forces with Hyatt. Just prior to that Hyatt had invented celluloid, and Lockwood came to Newark to serve as manufacturing superintendent of the Celluloid Corporation. Later he took over a similar position in another Hyatt enterprise, the Bonsilate Company of Albany, New York, manufacturers of plastics.

In the late 80's he returned to Newark, N.J., and worked with Mr. Hyatt on the sugar cane crushing machinery then occupying Hyatt's talents. From a bearing problem encountered on this machine was the Hyatt Roller Bearing conceived to overcome the difficulty. It did the job so well that after a few years the sugar machine idea was passed on to other hands, and Hyatt formed the Hyatt Roller Bearing Company with Lockwood as chief engineer.

It is interesting to note the prolific inventive minds of these two "partners", John Wesley Hyatt and C. S. Lockwood. In the name of Mr. Hyatt, who lived to be 83, there are upwards to 250 patents, and records show Mr. Lockwood to have nearly 100 patents in his name.

This venerable "co-founder" of their company will be greatly missed around the Hyatt plant, for not only was he a great inventor but a fine fellow, loved by all as the name of affection "Pop" Lockwood, bestowed on him, indicates, for "Pop" he was for years to his Hyatt associates, many of whom worked along with him for several decades, but still juniors to this congenial octogenarian.

Bridgeport Machine Company Doubles Capitalization

The Bridgeport Machine Company, whose factory and general offices are at Wichita, Kansas, has more than doubled its capitalization by the sale of 75,000 shares of its unissued common stock at $13 per share and an option to sell an additional block of 35,000 shares at $17 per share. This increases the company's capital and surplus from approximately $1,500,000 to more than $3,000,000. The increase in capitalization was made, it is understood, to be used as additional working capital to take care of the company's increasing business, and to further develop its oil producing properties in Kansas and Oklahoma.

Founded 29 years ago, Bridgeport has literally grown-up with the Mid-Continent oil industry. Its products, and those that it distributes for other well known oil equipment manufacturers, include practically everything used in producing oil and developing an oil property. Sales and distributing branches are maintained at Houston, Dallas, San Antonio, Tulsa, Oklahoma City, and Wichita. These distributing centers are surrounded by numerous branch stores, warehouses and material yards within easy reach of practically every oil field in the Mid-Continent and Gulf Coast.

Recently a new sales and service office was opened at 30 Rockefeller Center, New York City, to serve those operating companies who maintain executive and export offices in the East.

NATIONAL BANK OF TULSA

TULSA, OKLAHOMA

Statement of Condition March 4, 1936

RESOURCES

Cash and Due from Banks	$22,391,631.20	
U. S. Government Securities	13,180,603.94	
Other Bonds and Warrants	3,351,568.42	
		38,923,803.56
Loans and Discounts		14,919,733.94
Overdrafts		5,441.76
Income Receivable Accrued		145,632.43
Stock in Federal Reserve Bank		240,000.00
Investment in Bank Premises		2,206,000.00
Customers' Liability under Acceptances		8,486.25
TOTAL		$56,449,097.94

LIABILITIES

Deposits		$47,934,982.57
Acceptances Executed		8,486.25
Income Collected not Earned		60,832.85
Interest, Taxes, etc., Accrued		70,976.06
Capital—Preferred	$4,000,000.00	
Capital—Common	2,000,000.00	
Surplus	2,000,000.00	
Undivided Profits and Reserves	373,820.21	
		8,373,820.21
TOTAL		$56,449,097.94

COMPARATIVE DEPOSITS

March 5, 1934	$33,614,690.49
March 4, 1935	39,117,599.41
March 4, 1936	47,934,982.57

MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION

The Oil Bank of America

United Supply and Mfg. Co. Organized

H. B. GUTELIUS

The United Supply and Manufacturing Company, with headquarters in Tulsa, Oklahoma, has been organized by H. B. Gutelius and C. J. Halloran. Gutelius, president of the company, has been in the supply business for many years, having been with the National Supply Company for 14 years, and with the Continental Supply Company from 1925 to 1932. During the latter part of his affiliation with the Continental he acted in the capacity of president and director in charge of the Oklahoma division.

C. J. HALLORAN

C. J. Halloran, vice-president of the new concern, was connected with the Continental Supply Company for 19 years, most recently in the capacity of district manager for Oklahoma and Kansas with headquarters in Tulsa.

E. O. Monnett of Tulsa is secretary-treasurer.

The company will have three or more branch stores in Oklahoma, and begins operations with a capital of $100,000.

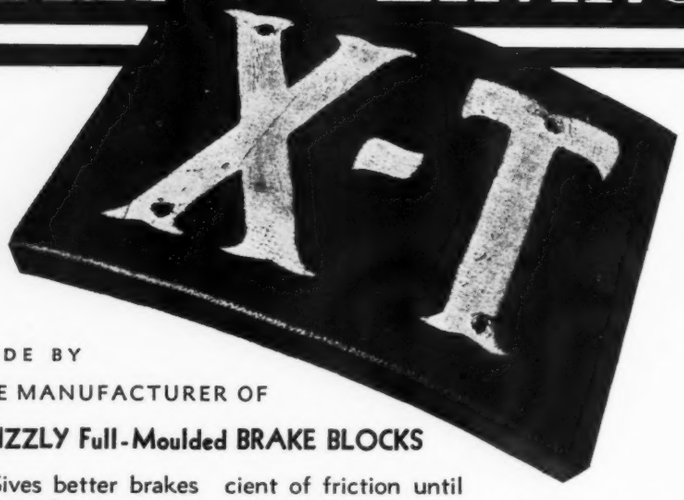
Crane Co., Chicago, announces the appointment of George L. Erwin, Jr., as assistant to P. R. Mork, vice-president in charge of sales. Erwin, to take up his new duties, resigned as general sales manager of Kearney and Trecker Corporation, Milwaukee. In his newly-created position of assistant vice-president of Crane Co., he will develop sales and market research activities.

M. T. "Kap" Kappele, Ponca City, Oklahoma, has been appointed representative in the central and western portions of Oklahoma and Kansas for the Exner-Dodge Packer Co., Coffeyville, Kansas. Kappele is widely and favorably known in his territory, for many years having represented manufacturers of oil field equipment.

Ernest F. Talmage has been engaged by National Tube Company as a special representative in promoting the sales of seamless alloy tubes in the refining field and for general industrial purposes. He comes to the National organization with a background of considerable experience with special steels, having been previously associated for a number of years with the Crucible Steel Company and Timken Steel and Tube Company.

C. C. Witt, chief clerk and purchasing agent of the Tulsa, Oklahoma, branch of the Parkersburg Rig and Reel Company, recently was made manager of the Kansas sub-district, his headquarters being in Wichita. G. G. Boyer succeeds him at Tulsa.

X-T WOVEN
High-Friction
BRAKE LINING



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Available In Any Length For Complete Coverage or 12-Inch Blocks; in any thickness desired.

Manufactured by
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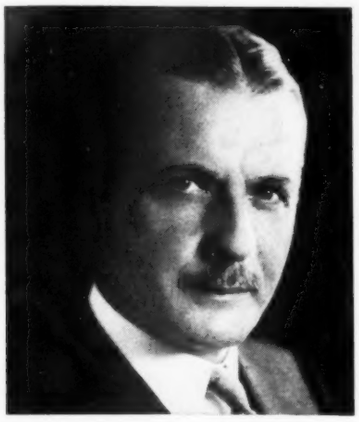
600-650 South Clarence Street, Los Angeles, California.
Manufacturer of GRIZZLY High Quality Oil Field Products.
Distributed by Continental Supply Company In All Their Stores.

Kauffmann Again Heads Link-Belt

At the annual meeting of shareholders held at the Stevens Hotel, Chicago, March 24, Alfred Kauffmann was elected president of Link-Belt Company. Kauffmann succeeds George P. Torrence, whose resignation as president and director of the company was accepted by the board the previous day.



ALFRED KAUFFMANN

Kauffmann started with the company 35 years ago as a draftsman. He was president of the company from 1924 to 1932, and has been a director since 1922.

The four board members elected to fill the terms expiring this year are Wellington Wells, Boston; J. Reece Lewis, Philadelphia; B. A. Gayman, San Francisco; Alfred Kauffmann, Chicago.

American Iron & Machine Works Co. Purchases Fittstown Plant

Effective April 1st, American Iron and Machine Works Company, Oklahoma City, Oklahoma, purchased and took over a plant at Fittstown, Oklahoma, formerly owned and operated by Mid-Co Tool and Supply Company. The new owners are enlarging the buildings and installing additional equipment. They are now giving complete machine shop service to the oil fields 24 hours each day seven days a week.

Ted Sawyer of Alexander Anderson, Inc., Fullerton, California, has been transferred from the Long Beach division to the Bakersfield division. In this new position he will continue his work in underground surveys of oil wells and directional drilling.

Unretouched snap shot shows how The Cavins bailed out 500 ft. of sand. Most of it was pulled from behind the perforations.

500 Ft. of Sand *bailed out by the*

CAVINS

The above photo was taken after The Cavins had cleaned out this well. The cellar is half filled with sand. Note where it has been running through derrick floor; also shovels where sand is being thrown off derrick floor.

The Cavins loads and unloads automatically in just a few seconds. Cleans out a well in about one-third the time required by other methods. The Cavins also cleans out sand bridged tubing; cleans the perforations thoroughly; and recovers "junk" of every description when a junk trap or basket is used on bottom. Operators make money every time they use it. Write for Bulletin and performance records.

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TAKE DEPTH
TAKE USE
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POMONA TURBINE PUMPS

Noted Diesel Designer Visits America

J. H. Pitchford, Diesel specialist and assistant to H. R. Ricardo of Ricardo and Company, research and consulting engineers of Shoreham, England, has been visiting in America, and consulting with the engineers and research staff of the Waukesha Motor Company and other licensees under the

Left: J. B. Fisher, chief engineer, Waukesha Motor Company; right: J. H. Pitchford, Diesel specialist and assistant to H. R. Ricardo, Ricardo and Company, Shoreham, England

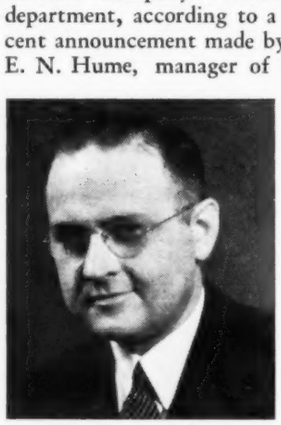
Ricardo patents for Diesel engines. Pitchford has been associated with the Ricardo Laboratories for ten years and has devoted the entire time to the research and development of the high-speed oil engine. The original research work done under the direction of Harry R. Ricardo that led to the Comet development was begun in 1930. It is said that regular visits are planned so that at six-month intervals either a representative of Ricardo and Company will be in this country, or one of the Waukesha Motor Company's staff of engineers will visit the Ricardo Laboratories in England.

Pitchford visited the large automotive centers before returning to England.

Wright and Runkle Promoted by General Electric

J. D. Wright and Karl H. Runkle have been appointed assistant managers of the General Electric Company's industrial department, according to a recent announcement made by J. E. N. Hume, manager of the

J. D. WRIGHT



K. H. RUNKLE

department. Prior to their promotions, Wright was assistant head of the industrial department's engineering staff and Runkle was manager of sales of the department's mining and steel mill section.

Champion Covering Oil Country

FRANK CHAMPION

Having left Los Angeles in March, Frank Champion, general sales manager for Byron Jackson Company, plans to spend two to three months motoring through the active fields of west and southwest Texas, Gulf coast areas, and southern Louisiana.

After attending the International Petroleum Exposition at Tulsa, where BJ will exhibit, Champion will visit the Oklahoma and Kansas oil country, before going on to New York in the interests of foreign sales for his organization.

George Christen to Manage New Crosby Steam Gage and Valve Company, Inc., of California

The formation of the Crosby Steam Gage and Valve Company, Inc., of California with offices, shops, and warehouses at 2034 Santa Fe Avenue, Los Angeles, has been announced. The new company will maintain a complete stock of Crosby safety and relief valves and gages. Shop facilities have been established for the repair and service of all types and makes of safety and relief valves and pressure gages, it is stated. George H. Christen, for many years sales engineer for valves and gages, is manager of the new company.

GEORGE H. CHRISTEN

Gotkool
WATER CANS & COOLERS

GOTT WATER CAN
Made in 1½, 3, 5, and 10 gallon sizes.

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Made in 3, 5, 8, 10 and 20 gallon sizes.

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KEEP PURE DRINKING WATER ALWAYS HANDY

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5 Types, All Sizes

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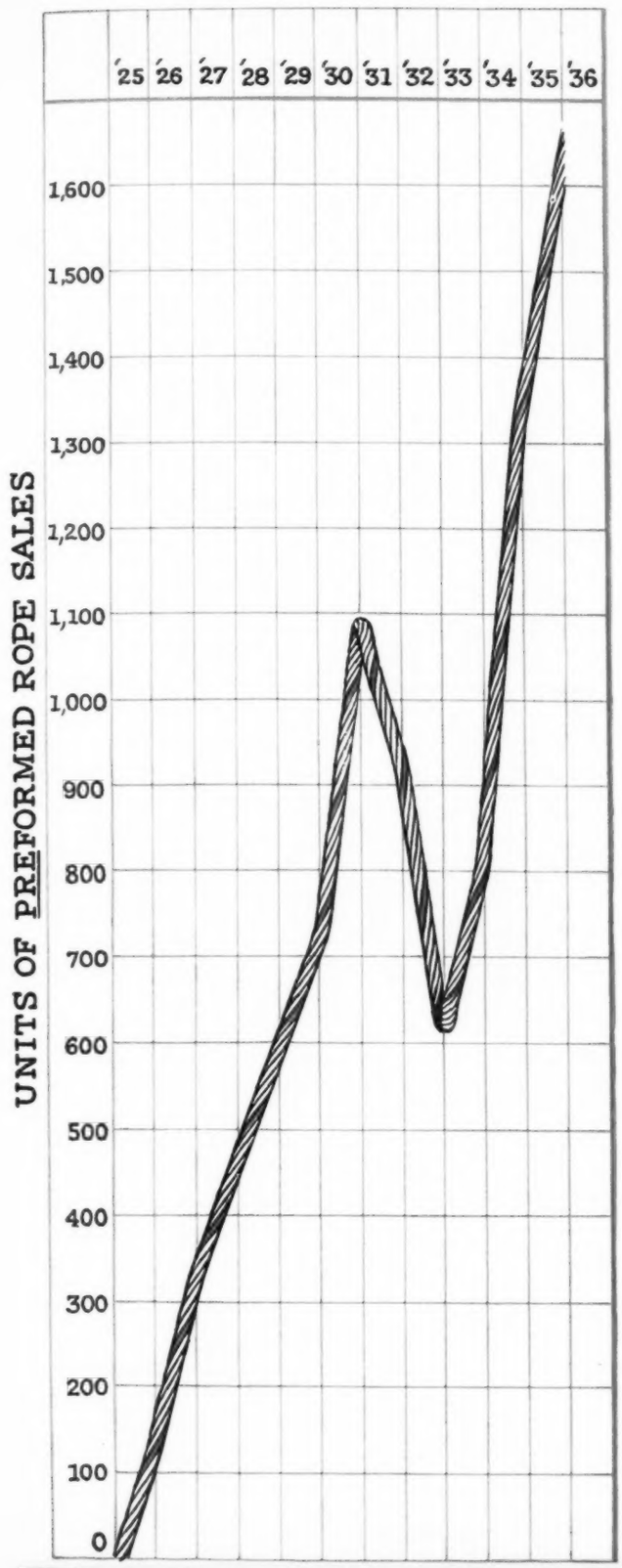

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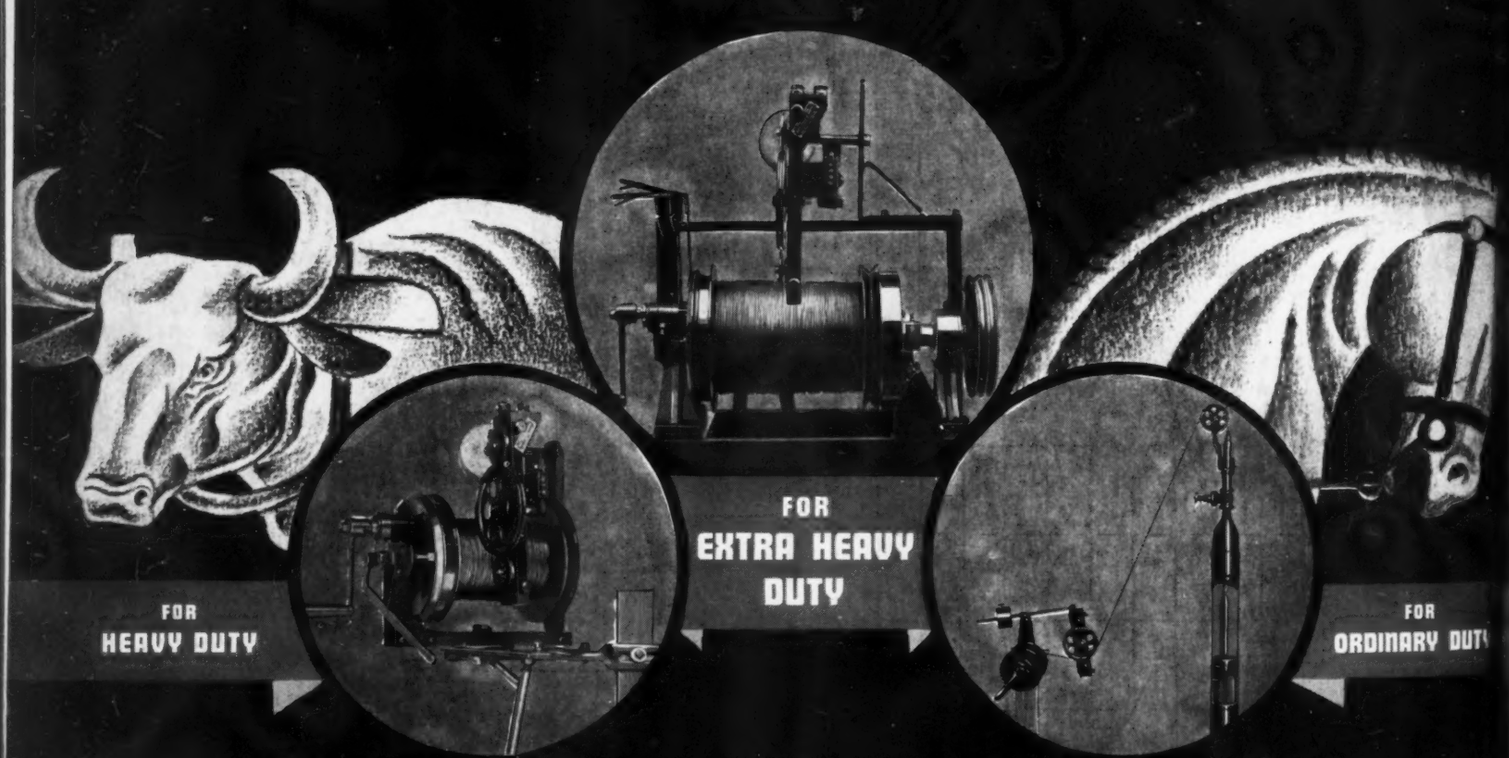

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